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ALFALFA-SEED PRODUCTION

J. W. CARLSON AND GEORGE STEWART

This sturdy plant grew from an alfalfa seed inherently vigorous. The importance of having more such plants in alfalfa-hay fields is apparent.

Utah Agricultural Experiment Station

UTAH STATE AGRICULTURAL COLLEGE

Logan, Utah

Alfalfa-Seed Production[1]

J. W. CARLSON AND GEORGE STEWART[2]

Utah's alfalfa-seed crop is of far-reaching importance. Since 1919, the growing of this crop has been a major industry in western Millard County and in that part of the Uintah Basin situated in Utah. These places are two of the relatively few large areas in the United States peculiarly adapted by climate for the successful growing of alfalfa-seed. As a cash crop, alfalfa-seed has a high commercial value. It is also the basis of the state's alfalfa hay crop, which in turn constitutes the foundation of Utah's livestock industry. Because of its wide dissemination, Utah's alfalfa-seed crop influences the feed supply of many states of America. As indicated in Figure 1, an increase in production of alfalfa-seed began in Utah in 1919 and continued until 1925, when it was estimated that 22,000,000 pounds were produced, with a total value of approximately $2,500,000. After 1925, there was a decline in yield and acreage harvested, until in 1929 and 1930 the annual production had fallen to approximately 3,000,000 pounds. An attempt to meet this emergency has been made through scientific investigation of production methods for alfalfa-seed.

EXPERIMENTAL FARM ESTABLISHED

Location and Object of Experimental Farm

The Uintah Basin Alfalfa-seed Experimental Farm is located at Fort Duchesne, near the geographical center of that part of the Uintah Basin situated in Utah. It was established in 1925 to make available to the public, with particular reference to conditions prevailing in the Uintah Basin, reliable commercial methods of producing alfalfa-seed. The importance of this crop to the farmers of this section is greatly enhanced by the fact that they are compelled by circumstances to produce a crop that is light, compact, and so valuable that it may be profitably transported by autotruck through a mountainous country to the railroad nearly 100 miles distant.

Acknowledgments: The authors freely acknowledge their indebtedness to the following: To William Peterson, Director of the Utah Agricultural Experiment Station at the time of the organization of this project, for valuable suggestions and encouragement at the commencement of this work; to P. V. Cardon, present Director, Utah Agricultural Experiment Station, for valuable suggestions and cooperation; to D. W. Pittman and D. S. Jennings, soils specialists at the Utah State Agricultural College, for assistance in selecting the site of the Experimental Farm; C. J. Sorenson, Associate Station Entomologist, for assistance in the control of insects injurious to alfalfa; Lealand A. Clark for assistance in the work on "Air Temperature and Relative Humidity in Relation to Seed-setting in Alfalfa"; to H. M. Tidwell, Superintendent, Uintah and Ouray Indian Agency, Fort Duchesne, Utah, and to County Commissioners of Uintah and Duchesne Counties, to C. H. Wilkinson, Manager of J. G. Peppard Seed Company, Roosevelt, Utah, and to F. O. Lundberg for their helpful cooperation; and to Robert Hall for valuable assistance in caring for the experimental work.

[1]Progress Report, 1925-1930, inclusive, on Station Project No. 75—"Uintah Basin Alfalfa-seed Experimental Farm."

[2]Assistant Agronomist and Superintendent of the Uintah Basin Alfalfa-seed Experimental Farm, and Agronomist, respectively.

Publication authorized by Director, April 15, 1931.

Soil of Experimental Farm

The Experimental Farm includes 40 acres of good land with dependable water-rights. The soil is deep and fertile, being composed largely of the accumulation of water-borne sediment. In soluble salt content, it is moderately high without being distinctly "alkali." The surface soil contains on the average about 740 parts per million (p.p.m.) sodium chloride, 3030 p.p.m. sodium bicarbonate, 1220 p.p.m. sodium sulphate, and about 25 p.p.m. nitric nitrogen. The average reaction is pH 7.5. In texture, the soil varies from coarse sand to fine clay. Drainage is free to a depth of approximately 10 feet, near which level a water-table is encountered.

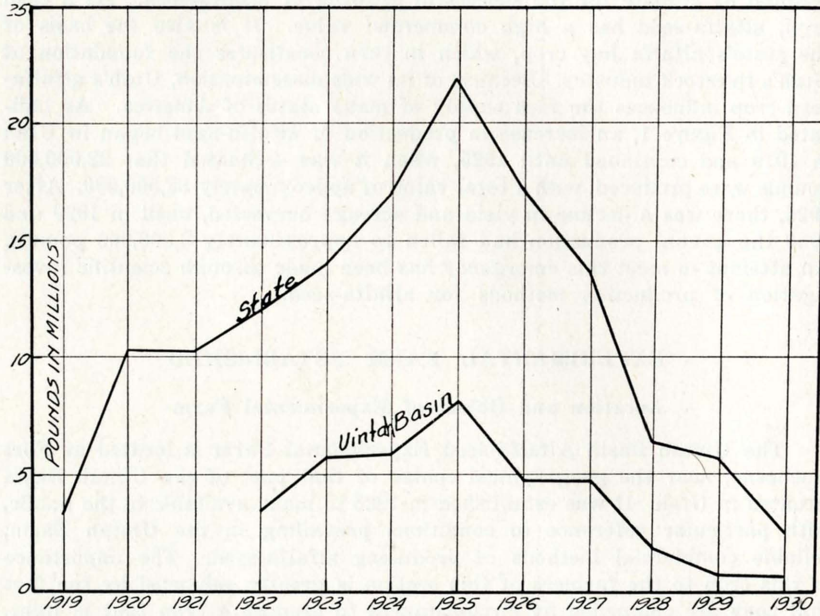

Figure 1—Showing total yield in pounds of alfalfa-seed for Utah* and the Uintah Basin, respectively, 1919-1920, inclusive.

*Estimate for state made by Bureau of Agricultural Economics; that for the Uintah Basin was prepared by C. H. Wilkinson, J. G. Peppard Seed Co., Roosevelt, Utah.

Plan of Farm

For experimental work, the farm area has been divided into 280 tenth-acre plats 38 x 114 feet. The plats are separated by 8-foot unplanted spaces, or alleyways, which are kept practically free from weeds at all times. At either end the plats are separated by 8-foot alleyways or 16-foot roadways which give access to the plats and facilitate cultural and harvesting operations. Figure 2 illustrates the general plan and manner of distributing the three replicated plats of each treatment, so as to share as equally as possible in the various soil and moisture conditions. A portion of the Ex-

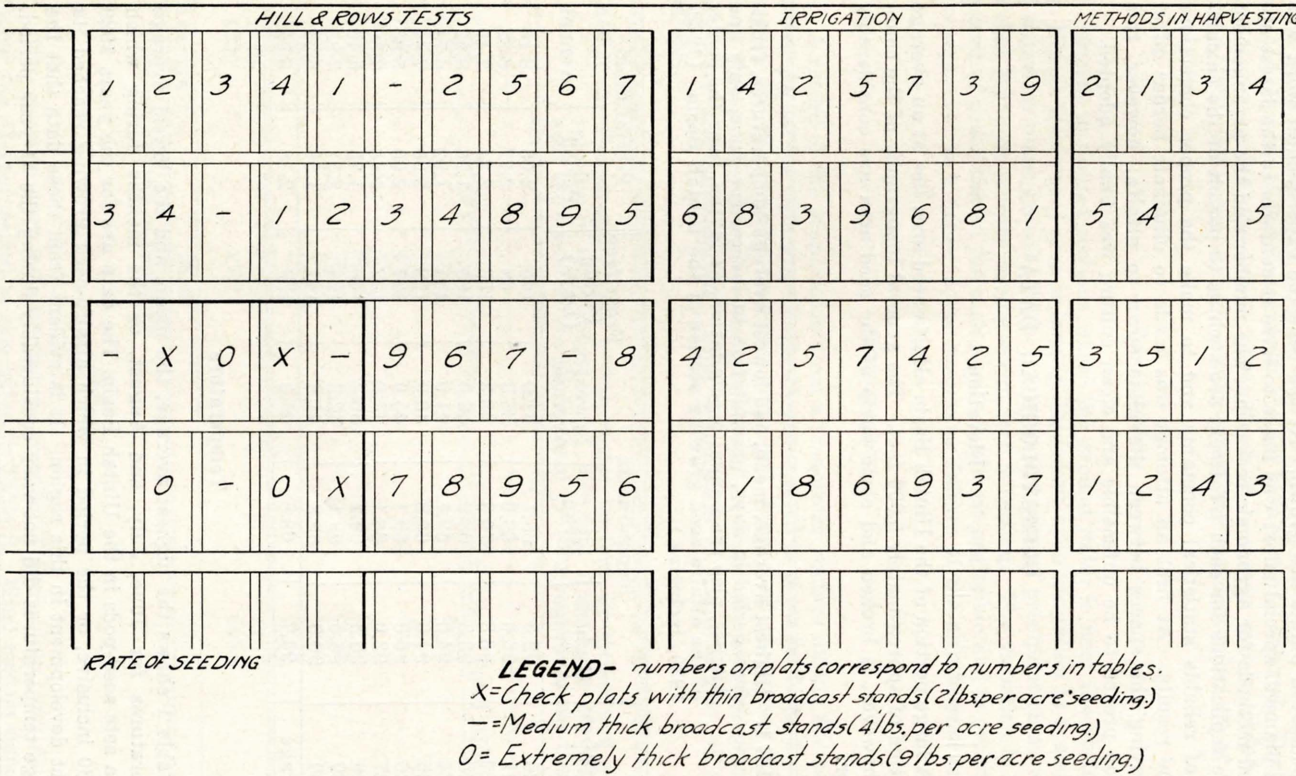

Figure 2—Showing a section of the Uintah Basin Alfalfa-seed Experimental Farm, illustrating the arrangement of the experiments and the replications of each treatment, so as to share as equally as possible in the various soil and moisture conditions. A total of 280 tenth-acre plats, 38x114 feet, is being used.

perimental Farm is used for an alfalfa nursery in which many selected and pedigreed plants are grown. At the time the experimental work was being planned, special effort was made to have it conform to the latest approved methods for agronomic research. The number and the arrangement of the replications for each treatment are such as to permit of the calculation of reliable statistical constants and to make the proper corrections on the results. At first an attempt was made to eliminate border effect by having the spaces between the plats sown to alfalfa; however, this method proved to be unfeasible and clean culture was finally adopted.

CLIMATOLOGICAL DATA[3]

Elevation

A large portion of the Uintah Basin alfalfa-seed area lies at an average elevation of approximately 5,000 feet. The general topography of the country, however, is broken and some parts of the seed area are considerably higher.

TABLE 1. Highest average, mean, and lowest average temperatures, frost-free period in days, precipitation in inches, for June, July and August, also the annual precipitation, at Myton, near the center of the alfalfa-seed growing section of the Uintah Basin. (1920-1930, inclusive.)

Year	Temperature			Frost-free Period (Days)	Precipitation	
	Highest Average	Mean	Lowest Average		Period	Annual
1920	92.6	68.1	41.0	146	2.00	8.16
1921	95.0	69.6	38.3	68	2.77	6.82
1922	96.3	70.6	43.3	153	2.24	7.40
1923	93.3	68.9	42.0	109	1.98	8.92
1924	94.0	69.1	41.0	131	1.02	4.71
1925	94.0	68.2	43.0	152	3.90	7.84
1926	95.6	69.1	45.0	137	2.00	5.36
1927	93.0	66.1	40.6	122	2.43	7.69
1928	95.3	69.2	36.3	140	1.75	5.46
1929	96.6	69.1	42.3	124	2.31	7.83
1930	96.0	69.8	41.6	141	1.59	6.25
Average	94.7	68.8	41.3	129	2.18	6.94

Temperature

Table 1 shows the highest average, the mean, and the lowest average temperatures for June, July, and August, or the months during which alfalfa sets seed-pods in the Uintah Basin. The data are for the years 1920 to 1930 inclusive, or the period in which alfalfa-seed growing reached its highest development in this region. It is evident from these data that the average temperatures did not vary considerably during the 11-year period.

[3]Data from U. S. D. A. Weather Bureau records taken at Myton, Utah.

The length of the frost-free period is also shown for each year, which in most of the years is sufficiently long to insure the proper maturing of the seed, provided clipping of the first-growth has not been too long delayed. During the 11-year period, the latest killing frost in a season was recorded on July 3, 1921, while the earliest autumn frost was on September 10 of the same year.

Precipitation

Except in limited sections where the ground water is near the surface, the Uintah Basin seed area is largely dependent upon irrigation as a source of water for plant growth. Table 1 includes the annual precipitation as well as that for those months during which seed is setting. The variation in the amount of precipitation for each month is almost negligible and is probably not important as a cause in the success or failure of the alfalfa-seed crop.

Evaporation

A record of the evaporation from a free-water surface during the seed-setting period for each year of the 11-year period is given in Table 2. The average for the months of June, July, and August of each year is 3.8 times the average annual precipitation and 12.1 times the average precipitation for the same period. High evaporation is characteristic of arid regions.

TABLE 2. Evaporation from a free water surface in inches and wind velocity in total miles, June, July and August, at Myton, or near the center of the alfalfa-seed growing section of the Uintah Basin, Utah. (1920-30, inclusive.)

Year	Evaporation (Inches)	Wind Velocity (Total Miles)
1920	22.90	4829
1921	24.50	4321
1922	25.52	4812
1923	28.82	*
1924	32.39	6852
1925	23.58	5016
1926	27.20	5430
1927	25.39	5510
1928	*	5384
1929	27.15	5153
1930	27.17	5094
Average	26.46	5240

*Data not available or incomplete.

Wind

The average wind velocity for the months of June, July, and August during the 11-year period is also given in Table 2. Wind seldom damages alfalfa-seed in the Uintah Basin, except as it may be accompanied by high temperatures. However, mature seed may sometimes be shattered by high winds, which may also interfere with harvesting and threshing operations.

EXPERIMENTAL WORK

The experimental work with alfalfa is being conducted along two lines: (1) To seek correct and practicable farming methods in relation to the production of alfalfa-seed and (2) to make technical studies of the alfalfa plant in relation to its improvement for general usefulness.

Methods of Seeding Alfalfa for Seed Production

SEEDING IN ROWS

Seeding Alfalfa in Rows Resulted in an Acre-Yield of Seed Approximately One-Third Greater than the Drilling Method

For many years it has been known that isolated plants of alfalfa set seed more profusely than those in all but the thinnest stands. The method of growing alfalfa in cultivated rows for seed production has been recommended for trial by research workers at various times[4]. For the purpose of determining the value of this method, in comparison with ordinary drilled stands, sowings have been made of Utah Common alfalfa in rows spaced 21, 28, 42, and 49 inches apart. Planting was done with grain drill, equipped with an attachment for sowing small seeds. By closing up a part of the holes in the seed-box, it was possible to space the rows at any desired distance which is a multiple of 7 inches. The amount of seed sown in each row is about the same as would be seeded in the rows when 5 pounds of seed is sown to the acre from the same drill when all of the spouts are open; no attempt was made to thin the plants in the row; therefore, a medium to rather thick stand was obtained. During the first season, the plats were kept free of weeds by means of horse cultivation and hand hoeing. With ample irrigation the plants attained to nearly full development the first year. In the spring of the following year, a springtooth harrow was run over the plats both lengthwise and crosswise of the rows, and a one-horse cultivator was used to keep the spaces between the rows free from weeds until the plants attained sufficient size to completely cover them. At harvest time the branches of the plants in widely spaced rows had to be turned back on the crowns to facilitate effective work by the reaper. To secure all of the seed and to obtain accurate yield data, some gleaning by hand between each round of the reaper was also necessary.

Check plats for this experiment were provided by planting series of plats of alfalfa with the seed drilled in the usual way. Three of these plats were sown at the rate of 2 pounds of seed to the acre, three others at the rate of 4 pounds, and a third set at the rate of 9 pounds of seed to the acre.

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[4]Brand, C. J. and Westgate, J. M., "Alfalfa in Cultivated Rows for Seed Production in Semi-Arid Regions." U. S. D. A. Bur. Plant Ind. Cir. 24:1-23 (1909).

TABLE 3. Acre-yields of seed for single plats of alfalfa grown in rows for seed production, the average of replicated plats for each year, and a summary of average acre-yields for a 3-year period. The relative acre-yield and the difference between the acre-yield of each spacing treatment and that of the check plats* compared with the probable error of the difference.

Treatment No.	Spacing (In.)	Year	Acre-yield of Recleaned Seed (lbs.) Replication 1	2	3	Summary of Replicated Plats for Single Years: Average Acre-yield (lbs.)	Relative Yield Check=100	Compared with Check Diff. / P. E	Summary of Data by 3-year Averages: Acre-yield (lbs.)	Relative Yield Check=100	Compared with Check Diff. / P. E.
1	21	1928	385	300	275	320.0 ± 20.64**	116.1	1.6			
		1929	230	120	155	168.3 ± 23.52	136.1	1.5			
		1930	195	175	105	158.3 ± 14.83	196.8	4.6	215.5 ± 11.54**	135.1	3.9
2	28	1928	420	335	175	310.0 ± 19.99	112.4	1.2			
		1929	205	120	70	131.6 ± 18.39	106.4	0.3			
		1930	205	180	105	163.3 ± 15.30	203.1	4.8	201.6 ± 10.39	126.3	3.1
3	42	1928	340	310	285	311.6 ± 20.09	113.0	1.3			
		1929	150	255	65	156.6 ± 21.89	126.6	0.8			
		1930	200	155	170	175.0 ± 16.39	217.6	4.6	214.4 ± 11.31	134.4	3.9
4	49	1928	282	295	260	279.0 ± 17.77	100.0	0.0			
		1929	110	205	150	155.0 ± 21.66	125.4	1.1			
		1930	210	195	220	208.3 ± 19.51	259.0	6.1	214.1 ± 11.38	134.2	3.7
	Check* (Average of 3 rates of seeding)	1928	270	271	286	275.6 ± 17.77	100.0				
		1929	180	110	81	123.6 ± 17.27	100.0				
		1930	118	88	35	80.3 ± 7.54	100.0		158.5 ± 8.63	100.0	

*Check plats have drilled ± stands of alfalfa approximately as thick as those in the average commercial fields.

**Figures in Tables 3-12, inclusive, preceded by a ± (plus and minus sign) give what is technically known as the probable error of the acre-yields. This is a standard measure of variability of plats receiving the same treatment. When these figures are added to and subtracted from the acre-yield, two limits are set up within which 50 per cent of the new acre-yields may be expected to fall if the same experiment is repeated under the same conditions an infinite number of times. On the basis of chance fluctuations, the remaining acre-yields will be above or below these limits.

A detailed consideration of the data in Table 3 shows the acre-yields of recleaned seed in pounds for single plats of alfalfa grown in rows and in the check plats for seed production. The average acre-yield of the replicated plats for each year and a summary of the yields for a 3-year period are also given. The average acre-yield for a 3-year period is approximately 32 per cent greater for the plats in rows, as compared with that of the checks which are representative of the stands of average commercial fields. This difference is statistically significant,[5] and, if the experiment were repeated under similar conditions, the same results on the basis of odds might be expected 22 times out of at least every 23 trials. In this experiment, various spacings of the rows gave no important differences in acre-yield of seed, notwithstanding the fact that plats having rows spaced 21 inches apart have 21 rows, while those having rows spaced 49 inches apart have nine only. Therefore, it would appear that when alfalfa is grown in rows for seed production, it would be spaced at a distance to best facilitate cultivation and harvesting operations, as the distance at which it is spaced does not appear to be important in seed production, at least within a considerable range.

These comparisons have been made on the basis of check plats having drilled stands ranging from extremely thin to extremely thick, but which on the average represent approximately stands in commercial fields. In Table 4 a comparison is made on the basis of the three check plats sown at the rate of 2 pounds of seed to the acre. The stands on these plats are thin, much thinner than those in the average commercial fields. When compared on this basis, the average acre-yield of the rows for the 3-year period is about 11 per cent greater than that of the check plats. The difference is not statistically significant, and since the acre-yields of the row plats were less than those of the checks one year in the three, it appears that a thin drilled stand, when kept free from weeds, might be found to be approximately as good for seed production as the rows. However, the problem of weed control would likely become a serious one when extremely thin drilled stands are used for seed production in alfalfa.

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[5]**Statistical interpretation of results:** The difference between the acre-yield of the respective treatments and that of the check plats, when divided by its probable error, gives the figures in the ninth and also the last columns of Tables 3-12, inclusive. When this figure is 1 and the experiment is repeated under similar conditions, the odds are 1 to 1 that the new results will be the same as those already obtained. When this figure is less than 3, the difference is said to have no statistical significance but may be attributed to chance fluctuations, random sampling, as well as to ordinary errors of even carefully conducted experimental work. When the relationship of differences in respect to their probable errors is more, it is said to be statistically significant, since it indicates that the differences are probably "real" and probably are not the result of chance variations or of errors within ordinary limits. When a difference is three times its probable error and the experiment repeated under similar conditions, only once in approximately 23 trials, as a result of chance, would there be a difference as large or larger than the one already obtained. When the difference is five times its probable error, the chances for a recurrence of a difference as large, on the basis of chance, would be once in approximately 1,350 trials. Differences which are statistically significant are thought to result from causes that operate somewhat independently of chance and error within ordinary limits. In these experiments the significant differences in acre-yield between a treatment and the check plats are believed to result from the treatment which is applied to one set of plats but which is not applied to the check plats. Since other conditions are approximately the same, they differ only in one respect, that is, in the treatment, which is believed to be responsible for the difference in acre-yield of seed.

This explanation is offered as an aid in the proper understanding of the data in Tables 3-12, inclusive.

TABLE 4. Acre-yields of seed for single plats of alfalfa grown in rows for seed production, the average of replicated plats for each year, and a summary of the average acre-yield of each 3-year period. The relative yield and the difference between the acre-yield of each spacing treatment and that of the check plats* compared with the probable error of the difference. (Same as Table 3, except based on different checks.)

Treatment No.	Treatment Spacing (In.)	Year	Acre-yield of Recleaned Seed (lbs.) Replication 1	2	3	Summary of Replicated Plats for Single Years: Average Acre-yield (lbs.)	Relative Yield Check=100	Compared with Check Diff. / P. E	Summary of Data by 3-year Averages: Acre-yield (lbs.)	Relative Yield Check=100	Compared with Check Diff. / P. E.
1	21	1928	385	300	275	320.0±21.31	118.5	1.7			
		1929	230	120	155	168.5±22.41	93.6	0.3			
		1930	195	175	105	158.3±11.85	133.8	2.7	215.0±11.68	113.5	2.9
2	28	1928	420	335	175	310.0±20.64	114.8	1.4			
		1929	205	120	70	131.6±17.50	73.1	1.6			
		1930	205	180	105	163.3±12.23	138.0	2.9	201.6± 9.90	106.4	0.8
3	42	1928	340	310	285	311.6±20.75	115.4	1.5			
		1929	150	255	65	156.6±20.82	87.0	0.7			
		1930	200	155	170	175.0±13.10	147.9	3.5	214.4±10.73	113.1	2.2
4	49	1928	282	295	260	275.6±18.35	102.0	2.1			
		1929	110	205	150	155.0±20.61	86.1	0.7			
		1930	210	195	220	208.3±15.60	176.0	5.0	212.9±10.56	112.4	1.6
	Check* (2 lbs. to the acre seeding.)	1928	260	245	305	270.0±17.98	100.0				
		1929	230	135	175	180.0±23.94	100.0				
		1930	145	125	85	118.3± 8.86	100.0		189.4±10.41	100.0	

*Check plats have drilled stands of alfalfa much thinner than those of the average commercial fields.

SEEDING IN HILLS OR CHECK ROWS

Growing Alfalfa in Hills for Seed Production gave an Increase in Acre-yield of Seed of Approximately 44 and 76 Per Cent, as Compared with the Rows and Drilling Methods, Respectively

During the progress of early investigations with growing alfalfa in cultivated rows for seed production, it was suggested that the plants should also be spaced thinly in the rows. This idea soon led to the development of the hill or check-row method of planting in which the plants are thinned out and spaced at a distance to permit of cultivation between rows in both directions. At the Experimental Farm tests have been conducted for the purpose of comparing acre-yields of seed when alfalfa is grown in hills with those obtained when grown in cultivated rows or drilled in the usual way. The plan of the experiment is similar to that described for row cultivation. Plantings were made in 28-inch rows, after which the plants were thinned out so as to secure the desired amount of space between them. In most cases single plants were left in each hill; occasionally, however, two or even three plants were left in a place. Since it was not always possible to align the plants in a straight line across the plat, a perfect check-row system was not attained. Five different spacings in three replications were used: 14 x 28, 21 x 28, 28 x 28, 35 x 28, and 49 x 28 inches. The same care was given to the plats in hills as for the rows, and the same check plats were used as a basis for comparison.

As shown in Table 5, for a 3-year period the average acre-yield is approximately 76 per cent greater for the plats in hills, as compared with that of the check plats which are representative of the stands in average commercial fields. When the average acre-yield of the hill plats is compared with check plats much thinner than those which are representative of commercial fields, the gain is about 49 per cent, as is shown in Table 6. These differences are "real," as is indicated by odds of many millions to one, and the cause may probably be safely attributed to growing the alfalfa in hills. For the 3-year period, the average acre-yield of the plats in hills is 44 per cent greater than the average of the plats in rows. Therefore, it is evident that in these experiments the hill method of growing alfalfa for seed production proved to be at least as much superior to the row method for producing high acre-yields of seed as the rows proved superior to the usual drilling method, when the stands are as thick as those of the average commercial fields. Just why the isolation of alfalfa plants increases seed production has not been fully determined. Some of the earlier investigators attributed it to an increased amount of sunlight and air available to the plants. In thick stands of vigorous plants the bloom is limited to the tips of the taller branches, whereas plants having sufficient space and equal illumination on all sides produce an abundance of flowers on all branches. In addition to limiting the amount of bloom, crowding of alfalfa plants checks the free circulation of air and might cause moist atmospheric conditions immediately surrounding the lower flowers. Shading has also been shown to be injurious to alfalfa-seed production.

As in the case of the rows, various spacings in hills show no important differences in acre-yield of seed, except probably when hills are spaced

TABLE 5. Acre-yields of seed for single plats of alfalfa grown in hills for seed production, the average of replicated plats for each year, and a summary of the average acre-yields for a 3-year period. The relative acre-yield and the difference between the acre-yield of each spacing treatment and that of the check plats* compared with the probable error of the difference.

No.	Treatment: Spacing (In.)	Year	Acre-yield of Recleaned Seed (lbs.): Replication 1	2	3	Summary of Replicated Plats for Single Years: Average Acre-yield (lbs.)	Relative Yield Check=100	Compared with Check Diff. / P. E	Summary of Data by 3-year Averages: Acre-yield (lbs.)	Relative Yield Check=100	Compared with Check Diff. / P. E.
5	14x28	1928	370	410	395	391.6 ± 11.16	142.6	9.2			
		1929	210	275	245	243.3 ± 25.83	196.8	4.1			
		1930	235	240	280	251.6 ± 18.97	312.9	8.6	295.5 ± 11.31	184.9	10.8
6	21x28	1928	400	365	350	371.1 ± 10.57	134.6	7.2			
		1929	235	230	245	236.6 ± 25.12	191.4	3.9			
		1930	325	260	305	296.6 ± 22.36	368.9	9.3	301.4 ± 188.7	188.7	10.92
7	28x28	1928	420	380	310	370.0 ± 10.54	134.2	7.1			
		1929	295	210	80	195.0 ± 20.70	157.7	21.9			
		1930	365	265	210	280.0 ± 21.11	348.2	9.0	281.6 ± 10.46	176.2	10.32
8	35x28	1928	335	305	375	338.3 ± 9.64	122.7	5.0			
		1929	260	205	155	206.6 ± 21.94	167.1	3.2			
		1930	265	300	270	278.3 ± 20.98	346.1	9.0	274.4 ± 10.61	171.1	9.6
9	49x28	1928	345	290	325	320.0 ± 9.12	116.1	3.7			
		1929	265	130	190	195.0 ± 20.70	157.7	2.9			
		1930	285	225	265	258.3 ± 19.47	321.2	8.2	257.7 ± 9.61	161.2	7.9
	Check* (Average of 2 lbs., 4 lbs. and 9 lbs., rate of seeding.)	1928	270	271	286	275.6 ± 7.85	100.0				
		1929	180	110	81	123.6 ± 13.12	100.0				
		1930	118	88	35	80.4 ± 6.06	100.0		155.8 ± 5.48	100.0	

*Check plats have drilled stands of alfalfa approximately as thick as those i n the average commercial fields.

TABLE 6. Acre-yield of seed for single plats of alfalfa grown in hills for seed production, the average of replicated plats for each year, and a summary of average acre-yields for a 3-year period. The relative acre-yield and the difference between the acre-yield of each spacing treatment and that of the check plats* compared with the probable error of the difference. (Same as Table 5, except based on different checks.)

Treatment			Acre-yield of Recleaned Seed (lbs.)			Summary of Replicated Plats for Single Years			Summary of Data by 3-year Averages		
No.	Spacing (In.)	Year	Replication 1	2	3	Average Acre-yield (lbs.)	Relative Yield Check=100	Compared with Check Diff. / P. E	Acre-yield (lbs.)	Relative Yield Check=100	Compared with Check Diff. / P. E.
5	14x28	1928	370	410	395	391.6±12.57	145.0	7.9			
		1929	210	275	245	243.3±21.28	135.1	2.3			
		1930	235	240	280	251.6± 7.62	212.7	15.3	295.5± 8.61	156.0	10.5
6	21x28	1928	400	365	350	371.1±11.91	137.4	6.8			
		1929	235	230	245	236.6±20.70	131.4	2.1			
		1930	325	260	305	296.6± 8.98	250.7	18.4	301.4± 8.49	159.1	10.7
7	28x28	1928	420	380	310	370.0±11.87	137.0	6.8			
		1929	295	210	80	195.0±17.06	108.3	0.6			
		1930	365	265	210	280.0± 8.48	236.6	17.5	281.6± 1.30	148.6	7.1
8	35x28	1928	335	305	375	338.3±10.85	125.2	4.9			
		1929	260	205	155	206.6±18.07	114.7	1.1			
		1930	265	300	270	278.3± 8.43	235.2	17.4	274.4± 7.81	144.8	8.5
9	49x28	1928	345	290	325	320.0±10.27	118.5	3.7			
		1929	265	130	190	195.0±17.06	108.3	0.6			
		1930	285	225	265	258.0± 7.82	218.0	16.2	257.7± 7.13	136.6	7.2
	Check* (2 lbs. to the acre seeding.)	1928	260	245	305	270.0± 8.66	100.0				
		1929	230	135	175	180.0±15.75	100.0				
		1930	145	125	85	118.3± 3.58	100.0		189.4± 6.10	100.0	

*Check plats have drilled stands of alfalfa much thinner than those of the commercial fields.

49 x 28 inches apart. It appears that these distances are near the limits within which the alfalfa plants are able to utilize economically for seed production the space available to each; to space them at greater distances would likely result in a decline in acre-yield of seed.

Rather limited tests at the Experimental Farm, have shown that old drilled or broadcast stands of alfalfa cannot be thinned out to approximate the thin stands and the hills used in these experiments with the same degree of success for seed production as when seed is sown on new ground and the plants are thinned out to the desired distance while still in the seedling stage. Alfalfa plants, like old trees, seem to be unable to make major changes in the habit of growth as they approach maturity. When grown in hills, some protection for the alfalfa seedlings against the invasion of weeds is usually necessary, in order that a large capacity for seed production may be developed during the first year.

SEEDING VARIOUS AMOUNTS OF SEED TO THE ACRE

Alfalfa Drilled so as to Produce a Thin Stand of Plants gave a Higher Acre-yield of Seed than did the Heavier Rates of Seeding

The plan of the experiment used to determine the proper rate of seeding alfalfa for seed production has been described in some detail, since these plats also served as checks in both row and hill experiments. It was thought that by planting as little as 2 pounds of seed and as much as 9 pounds of seed to the acre that stands of alfalfa could be secured which would range from thin to extremely thick. It was found, however, that thickness of stand in alfalfa is not always directly dependent upon the rate of seeding. The amount and frequency of irrigation, the condition of the seedbed, and the presence of weeds are also important factors in determining the percentage of seeds that germinate and establish strong seedling plants. Since these factors were kept as nearly uniform as possible, the different rates of seeding resulted in stands varying considerably in degree of thickness.

Data in Table 7 show the acre-yields of seed from the various rates of seeding to be nearly equal in 1928. The slight differences are statistically insignificant. This may be expected for the first season, since competition for space by the plants as a factor in seed production had as yet not become important. In 1929, the 2-pound seeding gave an average acre-yield approximately 37 per cent greater than that of the 4-pound seeding and about 59 per cent more than that of the 9-pound seeding. Similar differences in favor of the thinner stands are shown for 1930. The differences in acre-yield of seed did not begin to show until the plants were large enough so that competition for space was an important factor in seed production. Since the gains appear to favor the thinner stands, it would suggest a positive correlation between yield of seed and thickness of stand in alfalfa. The experiment has not been continued sufficiently long to establish the true relationship between these factors, since the relative degree of thickness of the stands in the plats apparently changes somewhat as the plants become older.

TABLE 7. **Acre-yields of seed for single plats of alfalfa sown at different rates of seeding for seed production, the average of replicated plats for each year, and a summary of average acre-yields for a 3-year period. The relative acre-yield and the difference between the acre-yield of each rate of seeding and that of the 4-pound-to-the-acre seeding, as the check, compared with the probable error of the difference.**

Treatment			Acre-yield of Recleaned Seed (lbs.)			Summary of Replicated Plats for Single Years			Summary of Data by 3-year Averages		
No.	Rate Acre-pounds	Year	Replication 1	2	3	Average Acre-yield (lbs.)	Relative Yield Check=100	Compared with Check Diff. / P. E	Acre-yield (lbs.)	Relative Yield Check=100	Compared with Check Diff. / P. E.
		1928	260	245	305	270.0±19.00	88.4	0.0			
1	2	1929	230	135	175	180.0±18.91	163.6	3.1			
		1930	145	125	85	118.3±22.11	133.9	1.0	189.4±11.58	120.9	2.2
		1928	295	270	250	271.6±19.12	100.0				
2	4	1929	180	85	65	110.0±11.56	100.0				
	(check)	1930	175	55	35	88.3±16.50	100.0		156.6± 9.26	100.0	
		1928	290	330	240	286.6±20.17	105.5	0.5			
3	9	1929	100	65	80	81.6± 8.57	74.1	1.3			
		1930	45	45	15	35.0± 6.54	39.6	3.6	134.4± 7.66	85.8	1.8

Clipping or Pasturing-off First-growth Alfalfa for Seed Production

For Best Results in Seed Production, Clipping of the First-growth Alfalfa Should not be Delayed Beyond the Beginning-of-Bloom Stage, and Pasturing-off Should not be Continued Later than the End of May

Many successful seed crops have been attributed to the plan of clipping or pasturing-off the first growth of alfalfa. Under the varying conditions of the different regions, it has not yet been determined what crop should be left for seed, since investigations on this point are inconclusive. Common experience in many of the large seed areas has been that in some years the first growth will produce the most seed while in others the second has been found to be the best. It appears that seasonal weather variations and insect injury are chiefly responsible for this condition, and it is doubtful if any one plan of clipping or pasturing-off the first growth will be found to be best for all years.

An experiment to measure the comparative value of a number of practices in clipping and pasturing-off alfalfa for seed production has been in progress for four years at the Uintah Basin Alfalfa-seed Experimental Farm. At the time the tests were started, the treatments used were thought to be sufficient in number and in type to represent most of the common methods used in commercial fields. The treatments have been applied in certain definite stages in the development of the plant rather than on specified dates. In this way, it was believed, that differences due to seasonal variations for the same dates could be partly eliminated and the treatments be made approximately the same for each year.

One set of three tenth-acre plats was clipped when the first growth of alfalfa had reached a height of 6 inches, which as a rule was some time during the second week in May. A second set was clipped ten days after the first. No hay could be gathered from these early clippings. A third set of plats was clipped when the flower buds were beginning to form, which was usually during the last week in May of each year. Some hay of good quality was obtained from this clipping, which under ordinary commercial methods would about pay for the cost of harvesting. A fourth set was clipped when the first flowers were observed, which as a rule was about a week after the bud stage. Another set was clipped when approximately one-tenth of the flowers were in bloom. Clipping at this time gave practically a full crop of hay. The last clipping for the season was applied to a set when the alfalfa was in full bloom or during the first week of July of each year. Two other sets of three plats each were provided with fences, and sheep were used to keep the alfalfa eaten close to the ground. On May 25th of each year the sheep were removed from the first set of these plats. Sheep continued to graze the other set until June 15th. Severe grazing by sheep appears to retard the vegetative growth of the alfalfa more than clipping, thus requiring a longer time to resume a vigorous second growth. Grazing also appeared to reduce the number of plants in the stand during the first season; however, this injury was not so apparent the following years. The practice of pasturing alfalfa fields with sheep during the spring months continuously over a period of several years has been known to promote the invasion of weeds to such an extent that they have presented a serious problem in alfalfa-seed production.

The check plats for this experiment consist of a set of plats on which the first growth was used for the seed crop. Since the first growth always had the highest acre-yield of seed, the treatment of the check plats continued the same for each year of the experiment. Another set of plats received no clipping or pasturing-off treatment, which in this case would have been the same regardless of whether the yield of seed was high or low. In other respects, all of the plats used for this experiment received similar treatment.

The season of 1927 in general was favorable for alfalfa-seed production at the Experimental Farm. Insect injury was relatively unimportant; uniform stands and regularity in development also seemed conducive to high acre-yields of good quality seed. Data in Table 8 show only small and statistically insignificant differences in the acre-yields of the plats clipped before or in the beginning of the bloom stage, as compared with those in which the first growth was left for seed. The 1927 acre-yields of the plats clipped in the tenth-bloom and full-bloom stages, or pastured-off until June 15th, on the average, are equal to about 50 per cent of those of the check plats. These low yields were apparently due, in part at least, to an insufficient time in which properly to mature the seed. The seasons of 1929 and 1930 were similar, generally unfavorable, and gave low acre-yields of seed on the plats comprising the clipping and pasturing-off test. During the early part of the seasons of these years, the alfalfa weevil did severe damage to the flowers on all the plats in which the first growth had been left for seed and those clipped in the early stages of growth. Grasshoppers, tarnish and superb plant bugs were relatively numerous and are believed to have done some injury to the later flowers. Some plats also appeared spotted as if they might have been suffering from insufficient water; however, an application of irrigation water to small affected areas resulted only in a second growth from the crowns which failed to produce seed.

The period over which these experiments have been conducted includes two years which were generally favorable for alfalfa-seed production and two which were not so favorable. It is not known how nearly these years represent the true average meteorological and biological factors influencing seed-setting in alfalfa. On the basis of a 4-year average, the differences in acre-yield of seed of plats clipped before the beginning-of-bloom stage, or pastured-off until May 25th, as compared with the check plats receiving no clipping are not statistically significant. The acre-yields of plats clipped after the alfalfa had entered the bloom-stage, or pastured-off until June 15th, on the average are approximately 55 per cent less than those of the check plats and probably are the results of a short season in which the seed did not mature properly. In general, the results of this experiment substantiate the common observations that in some years the first growth will produce the largest yield of seed, while in other years the second growth is found to be the best. For the Uintah Basin it also appears that clipping of the first growth of alfalfa for seed production should not be delayed beyond the beginning-of-bloom stage and pasturing-off should not be continued later than the end of May so that sufficient time may be allowed for the alfalfa-seed to attain proper maturity.

TABLE 8. **Acre-yields of seed for single plats of alfalfa clipped or pastured-off for seed production, the average of replicated plats for each year, and a summary of the average acre-yields for a 4-year period. The relative acre-yields and the difference between the acre-yield of each clipping or pasturing-off treatment and that of the check plats, compared with the probable error of the difference.**

No.	Treatment: First Growth	Year	Acre-yield of Recleaned Seed (lbs.): Replication 1	2	3	Summary of Replicated Plats for Single Years: Average Acre-yield (lbs.)	Relative Yield Check=100	Compared with Check Diff. / P. E	Summary of Data by 4-year Averages: Acre-yield (lbs.)	Relative Yield Check=100	Compared with Check Diff. / P. E.
1	Clip when 6 inches high	1927	474	415	375	421.6±62.01	95.8	0.2			
		1928	122	255	135	170.6±16.80	78.4	1.7			
		1929	17	20	21	19.3± 2.75	38.6	....**			
		1930	15	15	5	11.6± 1.83	10.5	....**	155.7±16.08	76.2	1.5
2	Clip 10 days after 6 inches high	1927	710	210	390	436.6±64.22	99.2	0.0			
		1928	160	95	135	130.0±12.80	59.8	3.5			
		1929	20	12	10	14.0± 1.99	28.0	....**			
		1930	15	5	15	11.6± 1.83	10.5	....**	148.0±16.38	72.4	1.9
3	Clip in bud stage	1927	665	240	440	448.3±65.94	101.6	0.0			
		1928	130	125	135	130.0±12.80	59.8	3.5			
		1929	12	7	12	10.0± 1.42	20.0	....**			
		1930	0*	0*	0*	0.0± 0.00	0.0	....**	147.0±16.30	71.9	2.0
4	Clip at beginning of bloom	1927	605	675	110	463.3±68.15	105.2	0.2			
		1928	225	285	100	203.3±20.02	93.5	0.4			
		1929	10	12	5	9.0± 1.28	18.0	....**			
		1930	0*	0*	0*	0.0± 0.00	0.0	....**	168.9±10.46	82.6	1.0
5	Clip at 1/10 bloom	1927	435	205	50	230.0±33.83	47.7	2.8			
		1928	160	110	100	123.3±12.14	56.7	3.8			
		1929	6	5	6	5.6± .79	11.2	....**			
		1930	0*	0*	0*	0.0± 0.00	0.0	....**	89.7± 8.99	43.9	5.4
6	Clip at full bloom	1927	265	185	170	206.6±30.39	46.9	3.2			
		1928	80	70	50	66.6± 6.56	30.6	6.7			
		1929	15	12	3	10.0± 1.42	20.0	....**			
		1930	0*	0*	0*	0.0± 0.00	0.0	....**	70.8± 7.78	34.6	6.5
7	Pasture with sheep until May 25	1927	560	580	325	488.3±71.82	110.9	0.5			
		1928	370	145	290	268.3±26.42	123.4	1.5			
		1929	62	73	32	55.5± 7.92	110.0	....**			
		1930	45	90	35	56.6± 8.93	51.4	....**	217.1±19.15	106.2	0.9
8	Pasture with sheep until June 15	1927	190	310	230	243.3±35.78	55.2	2.6			
		1928	280	180	195	218.3±21.50	100.4	0.0			
		1929	22	27	5	18.0± 2.57	36.6	0.0			
		1930	8	10	7	8.3± 1.31	7.5	....**	121.9±10.46	59.6	3.6
9	No clipping	1927	690	465	300	485.0±71.34	110.22	0.4			
		1928	190	165	170	175.0±17.23	80.5	1.5			
		1929	75	30	30	45.0± 3.57	90.0	....**			
		1930	95	135	40	90.0±14.21	81.8	....**	198.7±16.18	97.2	0.2
10	Check (No clipping)	1927	480	500	340	440.0±64.72	100.0	....**			
		1928	207	275	170	217.3±21.40	100.0	....**			
		1929	50	55	45	50.0± 7.14	100.0	....**			
		1930	95	185	50	110.0±17.36	100.0	....**	204.3±17.17	100.0	

*These yields were not actually zero but so low as to be practically immeas urable with the methods used. The actual yields are near that point and would apparently not have exceeded 5 pounds to the acre. Due to the apparently lo w yield, the seed on these plats was not harvested. However, it was thought best to represent them as zero and include them in the regular calculations. To have omitted them entirely would probably have introduced other and even greater sources of error.

**Data not calculated.

Cultivation of Alfalfa for Seed Production

Various Methods of Cultivating Alfalfa Produced no Important Differences in the Acre-yield of Seed. However, Spring Cultivation Aids in the Control of Weeds and Insect Pests

For many years spring cultivation of alfalfa for seed production has been a common practice in well-cared-for commercial fields. The object of cultivation is primarily for weed and insect control; in some cases a thinning of the stand is necessary to stimulate increased yields of seed. Various methods have been used. One which appears to be adapted for western conditions is described by McClymonds of the Idaho Agricultural Experiment Station.[6]

An experiment to gain some information on the value of different types of spring cultivation of alfalfa for seed production has been in progress at the Uintah Basin Alfalfa-seed Experimental Farm since 1927. The size of plats and the number and manner of replications are the same as have been described for other experiments. The first set of three plats was not cultivated for weed control. However, after the first season the stand of alfalfa was sufficiently thick to hold in check practically all of the weeds. A second set of three plats was given no cultivation, but the weeds were removed by hoeing or pulling by hand. Once each spring during the period of the test, a third set of plats received a heavy discing both lengthwise and crosswise of the plats. This treatment, which is severe, resulted in thinning the stand of alfalfa; however, the surviving plants appeared to be uninjured and made a vigorous vegetative growth. A fourth set of plats was cultivated, once during each season, with the springtooth harrow in both directions of the plat. Another set was given the same treatment as the fourth—once in the early spring and again about the middle of May of each year. In still another set, the alfalfa was grown in rows and, as long as the plants would permit, the intervening spaces were cultivated with a one-horse cultivator. Once during each season, the check plats were cultivated in one direction of the plats with the springtooth cultivator.

From the acre-yield data in Table 9, it is apparent that various methods of cultivating alfalfa produced no important difference in the production of seed during the 4-year period. The average relative yield of the plats in cultivated rows is 156.7, while the average of the average relative yields of the remaining plats, not in rows and which show no statistically significant differences in acre-yield of seed, is 124. The difference of 32.6 compares favorably with 32 per cent, which in Table 3 was found to be an average significant gain for plats in rows, as compared with check plats drilled in the usual way. Therefore, it is probable that the greater acre-yield for the rows in the experiment to test cultivation methods should be attributed to the effects of spacing rather than to those of cultivation. Replication 1 of the set receiving no cultivation but which was hoed for weeds was exceptionally well located with respect to soil conditions; it also had a thin stand, which may account for the high acre-yield for this treatment.

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[6]McClymonds, A. E., "Alfalfa-Seed Production in Southern Idaho." Idaho Agr. Exp. Sta. Bul. 143:1-20 (1926).

TABLE 9. Acre-yield of seed for single plats, of alfalfa receiving different cultivation treatment for seed production, the average of replicated plats for each year, and a summary of the average acre-yields for a 4-year period. The relative acre-yield and the difference between the acre-yields of each cultivation treatment and that of the check plats compared with the probable error of the difference.

	Treatment		Acre-yield of Recleaned Seed (lbs.)			Summary of Replicated Plats for Single Years			Summary of Data by 4-year Averages		
			Replication			Average Acre-yield	Relative Yield	Compared with Check	Acre-yield	Relative Yield	Compared with Check
No.	Cultivation	Year	1	2	3	(lbs.)	Check=100	Diff. / P. E	(lbs.)	Check=100	Diff. / P. E.
1	None	1927	580	385	210	391.6±54.00	130.5	1.3			
	(Let weeds	1928	155	137	146	146.0±16.06	143.7	2.2			
	go)	1929	20	55	0	37.5± 5.07	....*	....*			
		1930	10	15	65	30.0± 5.07	....*	....*	151.2±14.20	131.4	2.0
2	None	1927	500	520	390	470.0±64.81	156.6	2.2			
	(Hoe for	1928	280	150	145	191.6±21.07	188.5	3.7			
	weeds)	1929	50	55	25	43.3± 5.85	....*	....*			
		1930	105	40	115	86.6±14.64	....*	....*	197.8±17.66	172.0	4.0
3	One heavy	1927	520	225	345	363.3±50.09	121.1	0.9			
	discing in	1928	120	195	180	165.0±17.05	162.4	3.1			
	spring	1929	20	40	15	25.0± 3.38	....*	....*			
		1930	35	30	80	48.8± 8.16	....*	....*	150.4±13.41	130.7	2.0
4	Springtooth	1927	395	255	280	343.3±47.34	114.4	0.6			
	both ways	1928	165	65	105	111.6±12.45	109.8	0.5			
	once in	1929	75	70	65	70.0± 9.46	....*	....*			
	spring	1930	55	50	60	55.0± 9.30	....*	....*	144.9±12.68	126.0	1.8
5	Springtooth	1927	550	225	275	350.0±48.26	116.6	0.7			
	twice during	1928	160	55	100	105.6±11.61	103.3	0.3			
	season—early	1929	45	15	17	25.6± 3.46	....*	....*			
	and late	1930	30	15	10	18.3± 3.09	....*	....*	124.8±12.46	108.5	0.6
	spring										
6	Row cul-	1927	465	395	335	398.3±54.92	132.7	1.4			
	tivation	1928	260	175	199	211.3±23.24	207.9	4.3			
	28-inch	1929	85	50	60	65.0± 8.78	....*	....*			
	rows	1930	50	45	45	46.6± 7.88	....*	....*	180.3±15.20	156.7	3.5
7	Check	1927	545	130	225	300.0±41.37	100.0				
	(Springtooth	1928	135	65	105	101.6±11.17	100.0				
	one way once	1929	25	25	12	20.4± 2.75	....*				
	in spring)	1930	45	30	40	38.3± 6.47	....*		115.0±10.91	100.0	

*Data not calculated.

However, in alfalfa-seed production the practice of spring cultivation should continue because it aids in the control of weeds and insect pests.

Irrigation of Alfalfa for Seed Production

A Limited Water-Supply Which Will Produce a Slow and Even Vegetative Growth is Most Desirable for Seed Production in Alfalfa. The Amount Required Will Probably Vary With Soil Conditions and With the Seasons

The correct amount of soil moisture has long been regarded as one of the essential conditions for successful production of alfalfa-seed. The general opinion among growers is that limited irrigation sufficient only to produce a somewhat retarded growth of forage is better than too much water which tends to stimulate an excessive vegetative growth at the expense of seed production. This general rule has been found to be subject to many qualifying conditions, as soil types vary and sometimes a water-table is within reach of the alfalfa roots, which makes possible successful seed-growing without irrigation. A few growers have worked out fairly successful methods for the control of soil moisture for alfalfa-seed production in local areas, but invariably they agree that the same plan does not succeed every year.

A sandy to sandy-loam bottomland of medium fertility and with a water-table of from 6 to 12 feet below the surface has frequently been found to favor high acre-yields of alfalfa-seed. Some heavy soils, rather impervious to water, produce satisfactory seed yields, provided irrigation water can be applied in light applications at frequent intervals at the proper time. As a rule, deep, fertile soils which produce prolific hay-yields, are suitable for seed production only when natural moisture relationships are just right. Under soil conditions of this type, attempts to control the amount of water accessible to the alfalfa plants are usually unsuccessful. Many good seed crops have also been produced on wet alkaline lands. These general observations indicate that the problem of proper soil moisture for alfalfa-seed production is extremely complex.

An experiment to gain some information in regard to irrigation in alfalfa-seed production has been conducted at the Experimental Farm since 1927. The first set of three plats was irrigated during the late fall of the year preceding that in which the seed crop was grown. The second set was irrigated in the spring of the year in which the seed was produced. A third set received an irrigation at the same time as the second and again in the early part of August when the seed-pods were forming. A fourth set was irrigated during the third week in May; about one week later the first growth of alfalfa on these plats was clipped. Another set of plats was also clipped at this time; immediately after the hay was removed they were irrigated. One set of plats was irrigated when the plants were in full bloom, or during the early part of July. Irrigation was applied to another set when the pods were forming in August. Two sets of three plats each, which had received no irrigation during the four seasons, gave the highest average acre-yields of seed for the 4-year period. Since this treatment proved to be the best for seed production at the Experimental Farm, one of the sets is used as check plats for the test.

The amount of water applied to each plat was measured over a weir and is equal to an amount which, if spread to a uniform depth over the plat, would be approximately 4 inches. When applied after considerable vegetative growth of the plants had been attained, larger amounts of water were necessary to get a force sufficient completely to cover the plats. On the same basis, the amount used in these applications is equal to approximately 6 inches. A low dike was thrown up around the plat to hold the water until it could sink into the ground, after which no further control of its movement was attempted. It is possible that to some extent the water applied to one set of plats influenced others near by. The effect of the water on the rise or lowering of the water-table was not studied. Irrigation stimulated a vegetative growth which was greatly in excess of that produced on plats receiving no irrigation.

The yield data in Table 10, when averaged for the 4-year period or taken for each year, do not suggest any way in which the yield of alfalfa-seed may be controlled by the application of irrigation water. As an average, the highest acre-yields were produced on those plats receiving no irrigations; however, the differences between the average yields of these plats and those irrigated at various stages of plant development are probably not significant. On those plats from which the first growth of alfalfa was clipped in the bud-stage, followed by an irrigation as soon as the hay was removed, the second-growth produced an excellent hay crop; the yield of seed, however, was reduced to about 6 per cent of that of the check plats. This treatment resulted in low annual seed yields regardless of whether or not the season was favorable for alfalfa-seed production, whereas the yields resulting from some of the other treatments would vary somewhat according to the season. Of the plats receiving an irrigation after clipping the first-growth in the bud-stage, Replication No. 1 is located between two other plats, one of which is irrigated in the spring and the other when the pods are forming. In 1927, the two latter gave acre-yields of 640 and 410 pounds of seed, respectively, while the plat between them, having been clipped and irrigated, gave an acre-yield of 25 pounds. The difference was attributed to excessive stimulation of vegetative growth, due to the combined effects of clipping and of irrigation. A detailed consideration of the data of Tables 8 and 10 will support this conclusion.

Conclusions as to the proper time to irrigate alfalfa for seed production are indefinite. Consideration should be made of the fact that the Experimental Farm has a deep soil which is capable of retaining water to a high degree and a water-table is within reach of the alfalfa roots. Mention has also been made of the fact that no effort was made to control the movement of the water applied to the various plats after it entered the ground. In general, however, the results support the theory that a limited water-supply which will produce a slow and even vegetative growth is most desirable for seed production. Alfalfa used for seed production should not be allowed to "burn," but if not already available to the plants, the minimum amount of water necessary to produce a medium amount of forage and enough moisture to insure the proper maturing of the seed should be applied. This amount will probably vary with soil conditions and with the season.

TABLE 10. **Acre-yields of seed for single plats, of alfalfa receiving different irrigation treatments for seed production, the average of replicated plats for each year, and a summary of the average acre-yields for a 4-year period. The relative acre-yields and the difference between the acre-yield of each irrigation treatment and that of the check plats compared with the probable error of the difference.**

No.	Treatment: Irrigation (Time)	Year	Acre-yield of Recleaned Seed (lbs.): Replication 1	2	3	Summary of Replicated Plats for Single Years: Average Acre-yield (lbs.)	Relative Yield Check=100	Compared with Check Diff. / P. E	Summary of Data by 4-year Averages: Acre-yield (lbs.)	Relative Yield Check=100	Compared with Check Diff. / P. E.
1	One in	1927	431	265	470	388.6±49.31	76.3	1.4			
	fall	1928	252	95	170	172.3±25.81	82.0	0.9			
		1929	25	30	35	30.0± 2.96	25.7	7.3			
		1930	245	20	95	120.0±24.48	147.0	1.3	177.6±15.22	77.6	2.1
2	One in	1927	640	565	295	500.0±63.45	98.6	0.1			
	early	1928	172	220	41	144.3±21.61	68.7	1.7			
	spring	1929	50	70	90	70.0± 6.91	60.0	3.5			
		1930	25	220	75	106.6±21.47	130.6	0.9	205.2±17.70	89.7	0.9
3	One in early	1927	430	700	255	461.6±58.57	91.1	0.5			
	spring and	1928	135	120	60	105.0±15.72	50.0	2.9			
	one when	1929	105	75	135	105.0±10.37	90.0	0.7			
	pods are	1930	110	185	75	123.3±25.15	151.1	1.3	198.7±16.62	86.8	1.2
	forming										
4	One before	1927	385	400	30	271.6±34.46	53.6	3.2			
	clipping	1928	115	61	15	63.3± 9.48	30.0	4.4			
	(Clipped in	1929	3	4	5	4.0± .39	3.4	9.7			
	bud stage)	1930	15	20	15	16.6± 3.38	20.3	3.8	88.7± 8.94	38.7	6.8
5	One after	1927	25	20	45	30.0± .38	5.9	7.4			
	clipping	1928	15	15	12	14.0± 2.09	6.6	6.2			
	(Clipped in	1929	3	3	5	3.6± .35	3.0	9.8			
	bud stage)	1930	4	10	2	5.3± 1.08	6.4	4.5	13.2± 0.60	5.7	11.6
6	One in	1927	489	590	475	518.0±65.81	102.2	0.1			
	full bloom	1928	225	145	155	175.0±26.21	83.3	0.8			
		1929	115	50	110	9.16± 9.05	78.5	1.7			
		1930	210	50	70	110.0±22.44	134.8	1.0	223.6±18.72	97.7	0.1
7	One when	1927	410	270	650	443.3±65.25	87.5	0.7			
	pods are	1928	95	67	134	98.6±14.77	46.9	3.2			
	forming	1929	35	105	132	90.6± 8.95	77.7	1.7			
		1930	95	115	60	90.0±18.36	110.2	0.3	180.6±15.46	78.9	2.0
8	None	1927	640	625	630	631.6±80.15	124.6	1.2			
		1928	355	150	132	212.3±31.80	101.0	0.0			
		1929	200	115	110	141.6±13.99	121.4	1.3			
		1930	210	55	200	155.0±31.62	189.9	2.0	285.1±23.22	124.6	1.9
9	Check	1927	555	610	355	506.6±64.28	100.0				
	(None)	1928	270	255	105	210.0±31.45	100.0				
		1929	140	105	105	116.6±11.52	100.0				
		1930	85	80	80	81.6±16.64	100.0		228.7±18.59	100.0	

TABLE 11. **Acre-yield of seed for single plats of alfalfa receiving different manuring treatments for seed production, the average of replicated plats for each year, and a summary of the average acre-yields for a 4-year period. The relative acre-yield and the difference between the acre-yield of each manuring treatment and that of the check plats compared with the probable error of the difference.**

	Treatment		Acre-yield of Recleaned Seed (lbs.)			Summary of Replicated Plats for Single Years			Summary of Data by 4-year Averages		
	Manure		Replication			Average Acre-yield	Relative Yield	Compared with Check	Acre-yield	Relative Yield	Compared with Check
No.	Tons to Acre	Year	1	2	3	(lbs.)	Check=100	Diff. / P. E	(lbs.)	Check=100	Diff. / P. E.
1	5	1927	472	440	505	472.3 ± 27.77	89.9	1.2			
		1928	230	175	130	178.3 ± 22.46	128.2	1.3			
		1929	35	45	40	40.0 ± 3.72	58.5	....*			
		1930	15	25	45	28.3 ± 4.76	50.0	....*	179.7 ± 9.06	91.1	1.3
2	15	1927	490	460	380	443.3 ± 26.06	84.4	2.0			
		1928	54	120	120	98.0 ± 22.46	70.5	1.9			
		1929	45	40	25	36.6 ± 3.40	53.5	....*			
		1930	35	40	10	28.3 ± 4.76	50.0	....*	151.5 ± 8.72	76.8	3.6
3	Check (None)	1927	675	525	375	525.0 ± 30.87	100.0				
		1928	175	87	155	139.0 ± 17.51	100.0				
		1929	55	100	50	68.3 ± 6.35	100.0				
		1930	55	80	35	56.6 ± 9.52	100.0		197.2 ± 9.32	100.0	

*Data not calculated.

Manuring Practices for Alfalfa-seed Production

Acre-yields of Seed Were Highest for Those Plats Receiving No Manure and Lowest for Those Receiving 15 Tons of Manure

It is generally known that an application of barnyard manure to alfalfa will increase the production of hay when other factors influencing vegetative growth are also favorable. The effect of manure when applied to alfalfa for seed production is not so well known. To obtain some information on this point, manure was applied annually to a set of three tenth-acre plats of alfalfa at the rate of 5 tons to the acre and to another set at the rate of 15 tons to the acre. A third set of plats received no manure and was used as a check for the experiment. The manure was applied in the fall preceding each season in which seed was produced, as it was thought that the winter moisture would aid in carrying the soluble portion down to the roots and into the deeper soil layers. In the spring the plats were cultivated with the springtooth harrow or with a tractor-drawn alfalfa cultivator which would thoroughly mix the manure with the upper 4 or 5 inches of soil. First-growth alfalfa was used for the seed crop, and at no time since the year in which the seed was sown has it been necessary to irrigate the plats. Since irrigation was not used and the annual precipitation is less than 10 inches, the manure which was applied during one season did not decay and become incorporated with the soil before that of the following season was applied. As a result, those plats receiving manure at the rate of 15 tons to the acre had considerable manure on the surface which was not available to the plants as food.

The data in Table 11 indicate that the acre-yields for the 4-year period were highest for the check plats which received no manure, while those receiving 15 tons to the acre gave the lowest. The difference in yield is approximately 23 per cent. Since the results obtained from this experiment are not as conclusive as desired, it has been thought advisable to continue the investigation after making a few changes in the conditions. Under the new plan, the plats are to be plowed and the manure turned under, followed by a new stand of alfalfa. Irrigation water will be applied in quantities during the seedling stage of the new plants sufficient to enable the manure to decay and become incorporated with the soil. The effects of the manure after this treatment may then be sufficient to influence seed production in alfalfa.

Alfalfa Varieties for Seed Production

Winter-Hardy Varieties, Such as Grimm and Hardigan, can be Expected to be Equally as Good Seeders as Less Hardy Ones, such as Peruvian and Argentine. Utah Common Does Not Appear to Differ Greatly in Seeding Habit From Those Varieties Having Quality of Winter-hardiness or Lacking it

Considerable data have been made available from research studies which show the comparative value of the common commercial varieties of alfalfa for winter-hardiness and the production of hay. Since 1926, an attempt has been made at the Uintah Basin Alfalfa-Seed Experimental Farm to gain some information as to the relative value for seed production of twelve of the more common varieties and regional strains of alfalfa obtained from sources as follows (See also Table 12):

Variety	Source
Grimm Turkestan Dakota Common Peruvian Kansas Common Italian Argentine	Division of Forage Crops Investigations, Bureau of Plant Industry, U. S. D. A.
Hardigan	— Short pedigree seed from Michigan Farm Bureau
Ontario Variegated	— Pell Alfalfa-Seed Association, Brampton, Ontario, Canada
Cossack	— Short pedigree seed from local growers; origin traced to original plants introduced by U. S. Department of Agriculture
Grimm Saskatchewan 666	— College of Agriculture, University of Saskatchewan, Canada
Utah Common	— Unselected local strain

Sowings of each of the varieties and strains were made in tenth-acre plats replicated three times. Yield data have been secured for four years, two of which have been generally favorable for seed production.

On the basis of a 4-year average, as shown in Table 12, the group producing the highest acre-yields of seed includes Argentine, Utah Common, Hardigan, and Grimm. The intermediate group includes Italian, Cossack, Peruvian, Dakota Common, and Kansas alfalfas. Those producing the lowest acre-yields are Ontario Variegated, Grimm Saskatchewan 666, and Turkestan. While the data are not sufficient to furnish a basis for accurately judging the relative value of the varieties for seed production, they do show that winter-hardy varieties such as Grimm and Hardigan can be expected in some years to be equally as good seeders as less hardy ones, as Peruvian and Argentine. This at least may be expected to be true for the Uintah Basin. It also appears from these data that Utah Common does not differ greatly in seeding habit from those varieties having the quality of winter-hardiness or lacking it. Careful observations during these studies suggest that heavy seeding strains or lines might be developed from any of the varieties through suitable selection processes.

In these tests Peruvian alfalfa has proved to be susceptible to winter-killing. More than one-half of the plants in each plat of this variety were

TABLE 12. Acre-yields of seed for single plats of 12 varieties or regional strains* of alfalfa grown for seed production, the average of replicated plats for each year, and a summary of average acre-yields for a 4-year period. The relative acre-yield and difference between the acre-yield of each variety or regional strain and that of Utah Common alfalfa, as a check, compared with the probable error of the difference.

No.	Treatment: Variety Planted	Year	Acre-yield of Recleaned Seed (lbs.): Replication 1	2	3	Summary of Replicated Plats for Single Years: Average Acre-yield (lbs.)	Relative Yield Check=100	Compared with Check Diff. / P. E	Summary of Data by 4-year Averages: Acre-yield (lbs.)	Relative Yield Check=100	Compared with Check Diff. / P. E.
1	Grimm	1927	610	565	405	526.6±53.81	91.8	.4			
		1928	85	112	90	95.9±13.33	53.2	2.9			
		1929	15	3	3	7.0± 1.29	....**	....**			
		1930	75	15	55	48.3± 7.44	....**	....**	169.4±13.99	80.4	1.9
2	Hardigan	1927	670	570	430	556.6±56.88	97.0	.1			
		1928	175	120	85	126.6±17.61	70.3	1.7			
		1929	25	3	10	12.6± 2.32	....**	....**			
		1930	150	40	110	100.0±15.41	....**	....**	152.6±13.08	94.4	0.5
3	Cossack	1927	590	405	505	500.0±51.10	87.2	.7			
		1928	65	47	52	54.6± 7.59	30.3	4.7			
		1929	3	2	3	2.6± .47	....**	....**			
		1930	80	30	50	53.3± 8.21	....**	....**	152.6±13.08	72.4	2.8
4	Ontario Variegated	1927	190	330	260	260.0±26.57	45.2	3.7			
		1928	24	25	32	27.0± 3.75	15.0	6.0			
		1929	5	10	3	6.0± 1.10	....**	....**			
		1930	10	5	20	11.6± 1.78	....**	....**	76.1± 6.73	36.1	7.7
5	Turkestan	1927	180	80	295	185.0±18.90	32.2	4.7			
		1928	13	6	22	13.3± 1.85	7.3	6.6			
		1929	5	5	2	4.0± .73	....**	....**			
		1930	10	25	30	21.6± 3.32	....**	....**	55.9± 4.82	26.5	9.1
6	Grimm Saskat-chewan 666	1927	305	170	260	245.0±25.03	42.7	3.9			
		1928	37	35	17	29.3± 4.07	16.2	6.3			
		1929	3	2	3	2.6± .47	....**	....**			
		1930	15	35	30	26.6± 4.09	....**	....**	75.8± 6.42	35.9	7.7
7	Dakota Common	1927	405	305	595	435.0±44.45	75.8	1.5			
		1928	26	77	140	81.0±11.26	45.0	3.6			
		1929	2	3	3	2.6± .47	....**	....**			
		1930	15	20	50	28.3± 4.36	....**	....**	136.7±11.52	64.9	3.7
8	Peruvian	1927	500	450	400	450.0±45.99	78.4	1.3			
		1928	92	92	115	99.6±13.85	55.3	3.1			
		1929	5	1	5	3.6± .66	....**	....**			
		1930	0	0	0	0.0± 0.00	....**	....**	138.3±12.01	65.6	3.6
9	Kansas	1927	305	205	515	341.6±34.91	59.5	2.6			
		1928	42	40	75	52.3± 7.27	29.0	4.9			
		1929	12	10	15	12.3± 2.26	....**	....**			
		1930	40	15	25	26.6± 4.09	....**	....**	108.2± 8.99	51.3	5.5
10	Italian	1927	255	545	580	460.0±47.01	80.2	1.2			
		1928	35	122	130	95.6±13.29	53.1	2.9			
		1929	20	5	5	10.0± 1.84	....**	....**			
		1930	55	50	90	65.0±10.01	....**	....**	157.2±12.48	74.8	2.6
11	Argentine	1927	620	720	380	573.3±58.59	100.0	.0			
		1928	280	200	120	200.0±27.82	111.1	.5			
		1929	15	17	12	14.6± 2.69	....**	....**			
		1930	85	145	110	113.3±17.45	....**	....**	225.3±16.81	106.9	0.6
12	Utah Common	1927	700	565	455	573.3±58.59	100.0				
		1928	265	130	145	180.0±25.03	100.0				
		1929	10	10	13	17.0± 2.02	....**	....**			
		1930	100	35	100	78.3±12.06	....**	....**	210.6±16.22	100.0	

*For source of seed, see page 27.
**Data not calculated.

lost during the second winter. Italian and Argentine alfalfas also showed the effects of winter-injury but to a lesser degree than Peruvian. As compared with Utah and Dakota Common, the Kansas alfalfa strain used in this test showed considerable variegation in color of flowers. Ontario Variegated and Turkestan alfalfas developed extremely rank vegetative growth which probably prevented to some extent a high yield of seed. Grimm Saskatchewan 666 alfalfa shows a degree of uniformity of plant type and flower color that would seem to distinguish it from Utah Common alfalfa.

Time and Method of Harvesting Alfalfa-seed in Relation to Quality as Determined by Color and Condition of the Seed

It Appears that Stacking Cannot be Expected to Improve Greatly the Quality of Seed Cut in an Extremely Immature Condition. Quality in Alfalfa-seed Apparently Varies as a Result of Seasonal Conditions More Than it Does as a Result of Differences in Production Methods

In the Uintah Basin alfalfa left for seed is usually cut when about two-thirds of the seed-pods are black or brown. When cutting is delayed beyond this period, considerable seed is often lost by shattering in handling. When early frosts threaten, some growers believe that some injury is avoided by cutting earlier than at the stage of maturity mentioned and having the stems containing the seed-pods stacked for some time before threshing. To determine the effects on the quality of seed of early cutting and stacking, as compared with cutting at the usual time, an experiment has been conducted at the Experimental Farm during 1929 and 1930.

On five sets of three replicated plats, first-growth alfalfa was used for seed production. When approximately one-third of the seed-pods were black or brown, as determined from counts of random samples, the crops on the first set were cut and stacked when the leaves and stems became sufficiently dry. The crops on the second and third sets were cut when approximately one-half of the pods were ripe. The crop from one of these sets was stacked, while that from the other was threshed as soon as the stems and leaves were dry. The crops on the remaining sets received similar treatment after being cut at the usual time. It was believed that stacking would prevent a too-rapid drying of the stems and leaves, thereby allowing the immature seeds to continue to draw moisture and nourishment sufficiently to complete normal maturity.

After threshing, representative samples of seed from each of the plats were studied and worked into three classes based on color and condition. Seed which is plump and of a bright yellow or olive-green color represented true-color seed. Seed which is distinctly green or brown in color but plump constituted a second class. Shriveled seed which is also distinctly green or brown in color gave the third class. Table 13 gives the percentages of seed of each color class. The averages for the 2-year period show that the differences in the seed obtained from the various treatments are not large. A slightly lower percentage of true-color seed was obtained from the plats harvested when one-third of the pods were ripe. For this treatment, a

TABLE 13. The average percentages of true-colored (olive green) seed and of plump and shriveled discolored green or brown seed, from alfalfa harvested at different stages of maturity of the seed, threshed as soon as it became sufficiently dry or stacked for a period of a few weeks before threshing.

Treatment		Year	Quality and Condition of Seed					
			True Color		Plump Dis.		Shriveled Dis.	
No.	Method		%	Mean	%	Mean	%	Mean
1	Cut when one-third of pods are ripe and stacked	1929	77.6		12.2		9.7	
		1930	74.6	76.1	7.6	9.9	18.6	14.1
2	Cut when one-half of pods are ripe and stacked	1929	77.6		12.0		9.3	
		1930	82.6	80.1	7.6	9.8	9.6	9.4
3	Cut when one-half of pods are ripe and threshed	1929	74.5		15.8		12.6	
		1930	78.3	76.4	12.6	14.2	9.0	10.8
4	Cut at usual time and stacked	1929	81.0		8.6		9.5	
		1930	83.5	82.2	7.5	8.0	9.2	9.3
5	Cut and threshed at usual time	1929	81.8		7.8		9.7	
		1930	83.0	82.4	4.1	5.9	12.0	10.8

slightly higher percentage of shriveled discolored seed is also shown. Since the quality of the seed was determined from samples which had been threshed and re-cleaned under ordinary commercial methods, it is possible that the plats cut early produced considerably more shriveled and discolored seed than is actually shown in the percentage data. Seed of this type is relatively light and is easily blown out in the threshing and re-cleaning operations. Since its value as commercial seed was the point of investigation, no attempt was made to secure accurate yield data on the plats harvested at various times.

Table 14 gives data which indicate the effects of different clippings, cultivation, and irrigation treatments of alfalfa for seed production in relation to the quality of seed produced. The average of the analysis of seed taken from each plat for a 4-year period shows small differences in the percentage of true-color seed, except in the case of late clipping. A decrease in percentage of true-color seed with a corresponding increase in shriveled discolored seed may be expected from late clipping, due to a shortened season in which an insufficient time is allowed for the seed to develop to normal maturity. In the case of the remaining treatments the differences are probably too small to be important in commercial seed.

From these studies, it appears that stacking (while it has many advantages in the way of protecting the seed from rain and excessive drying which results in shattering) probably cannot be expected to improve greatly the quality of the seed cut in an extremely immature condition. It also appears that quality in alfalfa-seed varies more with the season than it does as a result of differences in the ordinary production methods used in the Uintah Basin.

TABLE 14. Showing the effects in relation to the quality of seed produced of clipping the first growth of alfalfa in various stages of vegetative growth, of irrigation at different times when other conditions for growth are the same, and of different types of cultivation applied in the spring.

Treatment		Average Quality and Condition of Seed for 4-year Period		
		Percentage		
No.	Method	True Color	Plump Discol'd	Shrvld. Discol'd
	Clipping First Growth			
1	When 6 inches high	75.7	12.3	12.0
2	10 days after No. 1	77.8	11.8	9.6
3	In bud stage	74.8	14.8	10.4
4	At beginning of bloom	69.0	17.3	12.9
5	At 1/10 bloom	61.4	17.5	21.0
6	At full bloom	50.5	21.6	27.3
7	Sheep-off early	79.8	9.6	11.4
8	Sheep-off late	77.5	11.9	10.5
9	No clipping (check)	78.6	12.0	9.8
	Cultivation			
1	None (let weeds go)	77.2	14.4	8.4
2	None (hoe for weeds)	80.6	11.0	8.3
3	Heavy discing	73.0	18.0	8.9
4	Both ways once	72.8	16.9	10.0
5	Row cultivation	77.6	12.1	10.2
6	One way once (check)	73.0	17.1	10.2
	Time of Irrigating			
1	One in fall	74.3	16.5	9.1
2	One in early spring	78.4	12.8	9.4
3	Early spring and when pods form	70.3	16.2	13.1
4	One before clipping	75.5	14.6	9.7
5	One after clipping	74.8	14.1	11.4
6	One at full bloom	77.7	13.2	9.0
7	When pods form	78.9	11.5	9.4
8	None	81.5	10.4	7.7
9	None (check)	79.3	11.2	9.3

Quality in Alfalfa-Seed as Determined by Color and Condition

When Grown Under Favorable Field Conditions, True-colored and Plump Alfalfa-seed has a Germination Value of Approximately 51 Per Cent; Plump Discolored Seed Has a Value of 29 Per Cent; and Shriveled Discolored Seed a Value of Approximately 16 Per Cent. Irrespective of Color or Plumpness, Approximately 75 Per Cent of the Alfalfa-seed That Germinated to the Field Established Strong and Healthy Seedling Plants

The color and plumpness of alfalfa-seed have long been accepted as influencing its market value. An earlier experiment[7] has established that there were rather wide differences in the germinating power of alfalfa-seed of various colors and of different degrees of plumpness. In the first place, it was shown that germination studies on blotting paper gave a considerably higher percentage of sprouts, especially for the discolored seed fractions than when the seedlings from the same seed were compelled to penetrate ⅜ inch of sandy loam. These differences are briefly summarized in Table 15.

TABLE 15. Summary of laboratory germination studies on blotters and in soil with alfalfa-seed of various colors and maturity fractions.

Seed Fraction	Germinated on Blotters	Germinated in ⅜ inch Soil
True Color	68.8	59.0
Light green	67.4	33.8
Light brown	67.0	45.2
Dark green	53.0	34.0
Dark brown	40.0	14.6
Shriveled green	25.4	4.4
Shriveled brown	41.8	9.0

Another experiment, replicated three to five times and repeated seven times, studied the effect of the same color and maturity fractions on the percentage of seedling plants which established themselves in the laboratory after coming through ⅜ inch of sandy soil. These results were:

Color Fraction	Percentage Plants Established
True Color	65.1
Light green	58.8
Light brown	53.6
Dark green	45.3
Dark brown	40.5
Shriveled green	24.2
Shriveled brown	18.7

In order to test the value of seed of various colors and conditions in regard to maturity and plumpness, a thorough study was undertaken with alfalfa-seed gathered from various growers in the Uintah Basin. Such lots of seed were selected as would give the various color separates desired. One lot of seed was scarified in a commercial scarifying machine. The seven color separates were made by hand from each lot. At one sowing 50 seeds of each color separate with two unseparated bulk checks were seeded in

[7]Stewart, G., "Effect of Color of Seed, of Scarification, and of the Dry Heat on the Germination of Alfalfa-Seed and Some of Its Impurities." In Jour. Amer. Soc. Agron., Vol. 18:743-760 (1926).

short rows in wood boxes set in a metal container in which water was placed for irrigation and covered with 3/8 inch of soil. At the same time a similar sowing was made for the scarified seed, except that none of the check rows seed was scarified. In all, there were 18 trials, a summary of which is presented in Table 16. Some seeds sprouted but failed to emerge, though no evidence of disease could be seen. These were classified as "weak." Other sprouts which were attacked by fungi and died were classified as "moldy."

TABLE 16. Percentages of germination, of weak sprouts, of moldy sprouts, and of healthy vigorous plants in normal and scarified alfalfa-seed, together with the relative value of the various color separates compared with unseparated bulk seed (Check=100)

Color Separate	Total Germ		Weak and Moldy		Net—Healthy and Vigorous			
	Normal	Scarified	Normal	Scarified	Normal	Scarified	Mean	Relative
Unseparated Check	55.8	54.3	5.0	5.3	50.8	48.9	49.5	100
True color	59.4	75.0	4.0	11.9	55.4	63.2	60.5	122
Light green	49.2	68.4	5.6	15.9	43.6	52.5	49.5	100
Light brown	31.2	46.6	7.6	13.7	23.6	33.9	30.5	62
Dark green	34.8	35.0	8.0	10.8	29.8	24.2	26.1	53
Dark brown	18.2	28.5	3.6	7.7	14.6	21.0	18.9	38
Shriv. Green	25.6	27.5	9.8	10.0	15.8	17.5	16.9	34
Shriv. Brown	7.6	16.9	1.8	5.3	5.8	11.6	9.7	20
Mean	32.3	42.6	5.3	10.7	26.9	32.0	30.3	61
Relative	100.0	132.0	16.0	35.0	84.0	97.0	94.0	

The total germination of the scarified seed was appreciably higher than for the unscarified. On the average, however, there were about twice as many weak and moldy sprouts in the scarified lots. There were also more total healthy vigorous plants from the scarified seed on account of considerably higher germination. The relative value as determined from laboratory tests of scarified and normal seeds may be listed as follows:

Normal	Relative Value	
	Normal	Scarified
Total germination	100	132
Weak, moldy sprouts	16	35
Healthy, vigorous plants	84	97

The relative value of the various color separates when compared with checks, of which four were grown in each of 18 trials, is shown by the following listing:

	Relative Value
All checks (unseparated bulk)	100
True color	122
Light green	100
Light brown	62
Dark green	53
Dark brown	38
Shriveled green	34
Shriveled brown	20

Bright true-colored (olive green) seeds were found to be 22 per cent more effiicient than ordinary unseparated bulk seeds or than seeds that were faintly green-colored and which proved just equal to the bulk. Discolored seed decreased in value until shriveled dark brown seed was only 20 per cent as capable of producing good plants as the bulk seed and only about 15 per cent as efficient as the bright true-colored seed separate.

TABLE 17. **Germination of variously colored alfalfa-seed separates sown in the field on three different dates and replicated 14 times in the three sowings combined. The seeding was done in 1929 from seed grown in the two previous years, 1927 and 1928. The relative germinating values are also given by calling the check 100.**

Color and Grade of Seed	Seed From Year	Planting Period	Avg. 14 Replications, Percentage Seeds Germinating, and P.E. in Units on This Basis	(Mean, 2 seasons)	Relative Value in Percentage on Basis of Check as 100 Per Cent
Check (Unseparated)	1927	June 20	53.0±1.89		
		July 8	49.3±2.11		
		July 23	45.2±2.59	42.1±0.79	100.0
	1928	June 20	40.3±1.17		
		July 8	33.1±2.05		
		July 23	31.9±1.60		
True Color (Bright and plump)	1927	June 20	64.2±1.16		
		July 8	63.5±2.35		
		July 23	44.4±2.81	51.2±0.79	121.6
	1928	June 20	53.7±1.71		
		July 8	43.7±1.68		
		July 23	37.9±1.58		
Plump Discolored	1927	June 20	38.1±1.71		
		July 8	31.7±1.52		
		July 23	29.7±1.12	29.9±0.57	71.0
	1928	June 20	32.4±1.51		
		July 8	25.3±1.25		
		July 23	22.7±1.28		
Shriveled Discolored	1927	June 20	26.0±1.19		
		July 8	22.5±1.82		
		July 23	21.9±1.21	16.7±0.46	39.6
	1928	June 20	11.5±0.68		
		July 8	9.0±0.85		
		July 23	9.6±0.74		

Germination Studies in the Field

In order to find if the color separates would give similar results in the field and as in the laboratory, small field seedings were made. Somewhat less careful sortings of alfalfa-seed were made into (1) true-color, (2) plump-discolored, and (3) shriveled-discolored separates, no effort being made to separate the green from the brown discolorations.

In 1929, plantings were made on June 20, on July 8, and on July 23, using 1927 seed in one set and 1928 seed in another. In 1930 there was one seeding each with 1927, 1928, and 1929 seed. At each planting the three seed separates and the check for each seed crop was used. This made eight sorts of seed in the 1929 sowings and twelve in the 1930 sowings. At each planting date eight replications of each sort of seed were made. In Table 17 is given a summary of the data obtained in 1929. There were slight differences in the germination when the same seed was sown on different dates, but the really noticeable difference is between the color separates which are 51.2, 29.9, and 16.7 per cent for true-colored, plump-discolored, and shriveled-discolored seed, respectively, as compared with 42 per cent for the unseparated check seed. These differences between the color separates and the checks are statistically significant and probably are due to differences in the actual germinating value of the seed.

In 1930 there was only one seeding date. The data for this year are summarized in Table 18. The germinations are all slightly lower than in the preceding year and the 1928-seed crop germinated uniformly less than did the other two. The order and the differences are about the same as for the 1929 seedings. The average percentages are 39.6 for the check as compared with 46.4, 26.4 and 12.1 for the true-colored, plump, discolored, and shriveled-discolored separates.

TABLE 18. Percentage germination as healthy vigorous plants from the variously colored separates of alfalfa-seed. One sowing was made in the spring of 1930 from seed grown in the three preceding years, 1927, 1928, and 1929. The relative ability of each color separate to establish plants is shown when the checks are called 100.

Color and Grade of Seed	Season	Average (10-14 replications) Germination and P. E. in Units of Same Basis	(Mean, 3 seasons)	Rel. Val. in Percentage on Basis of Check as 100%
Check (Unseparated)	1927	45.1±3.42		
	1928	31.4±1.68	39.6±1.56	100.0
	1929	42.5±2.73		
True Color	1927	51.6±3.01		
	1928	36.5±2.12	46.4±1.58	117.1
	1929	51.3±3.02		
Discolored Plump	1927	24.2±1.63		
	1928	19.5±1.37	26.4±0.97	66.6
	1929	35.5±1.99		
Shriveled Discolored	1927	18.0±1.46		
	1928	7.5±0.79	12.1±0.64	30.6
	1929	10.8±1.00		

Since the laboratory tests had shown a rather high percentage of weak or moldy sprouts, data were also taken in the field on the difference in the percentage of germination and the percentage of plants established. Table 19 summarizes these data and shows that from 16 to 32 per cent of the germinated seedlings died before establishing themselves in the field.

TABLE 19. Percentage of the germinated seeds which established themselves as healthy vigorous plants, together with the relative value of the various color separates, based in one case on the germinating quality and in the second case on the seedlings which grew and established themselves.

Seed Sort	Year in which Seed was Grown	Percentage of Germinated Sprouts which Grew: Average by Seed Crop	Percentage of Germinated Sprouts which Grew: Grand Average	Relative Value Check=100: Based on Germination	Relative Value Check=100: Based on Seedlings which Grew
Sowings of 1929					
Check	1927	81.8			
	1928	85.0	83.4	100	100
True-color	1927	86.0			
	1928	83.2	84.6	128.3	133.7
Plump	1927	81.3			
Discolored	1928	75.1	78.2	72.9	66.3
Shriveled	1927	75.8			
Discolored	1928	78.7	77.3	37.5	34.8
Sowings of 1930					
Check	1927	77.3			
	1928	79.6	79.1	100	100
	1929	80.5			
True-color	1927	76.5			
	1928	77.8	77.1	117.0	114.1
	1929	77.1			
Plump	1927	83.0			
Discolored	1928	77.9	78.0	66.9	65.7
	1929	73.2			
Shriveled	1927	69.4			
Discolored	1928	64.0	68.6	29.6	25.9
	1929	72.2			

Laboratory and field tests are compared in Table 20. As might be expected, there was a lower percentage of seeds germinating in the field than in the laboratory. There is a difference of from 55.1 to 40.9 per cent for the unseparated check seed and one of from 67.2 to 48.8 for the true-

TABLE 20. Comparative germination, plant establishment, and relative value of variously colored seed separates when tested in the laboratory and in the field. The seeds used in the field tests were not graded into so many color classes and these were broader classes.

Seed Sort	Germination		Plants which Grew		Relative Value (Check=100)	
	Lab.	Field	Lab.	Field	Lab.	Field
Check	55.1	40.9	49.5	34.3	100	100
True color	67.2	48.8	60.5	47.3	122	138
Lt. green	58.8		49.5		100	
Lt. brown	38.9	28.1	30.5	25.7	62	
Plump						75
Dk. green	34.9		26.1		53	
Dk. brown	23.4		18.9		38	
Shriveled						
Dk. green	26.6	14.4	16.9	11.2	34	33
Dk. brown	12.3		9.7		20	
			30.3			

colored separate. In the discolored fractions there was not much difference in the field and in the laboratory, though the dark green and dark brown seeds are woefully weak as compared to the bulk seed or to the true-colored separate. It is noteworthy, however, that 75 per cent of the plump discolored seeds which germinated in the field established themselves as healthy plants as compared with an average of about 64 per cent in the laboratory.

It is to be emphasized, therefore, that field germination was about 15 per cent lower than that in the laboratory. About 75 per cent of the seeds which germinated in the field became strong, healthy plants. This percentage of establishment was approximately the same irrespective of the color and quality.

Seasonal Behavior of Alfalfa Flowers in Relation to Seed Production[8]

When Alfalfa Fields Remain Unduly Long in Full Bloom Without Showing a Tendency to Change, the Chances Are Great that a Poor Seed Crop Will Result. No Visible Effects or Differences Are Apparent by Which Those Flowers Inclined to Set Seed-Pods Can be Distinguished From Those Having a Tendency to Strip

It has been generally supposed, at least by some alfalfa-seed growers in the Uintah Basin, that, if a high yield of seed is to result, the changes in development of the flowers after it comes into full bloom and while the

[8]Carlson, J. W., "Seasonal Behavior of Alfalfa Flowers in Relation to Seed Production," Jour Am. Soc. Agron. 20:542-556 (1928).

seed-pods are forming should occur in rather rapid succession. In other words, conditions are not considered favorable for seed production when flowers remain in the fresh-looking full-bloom stage for many days without showing a tendency to wilt or when they remain in the wilted stage unduly long before showing a tendency to form seed-pods. To gain further information on this point, observation was made of more than 3,000 alfalfa flowers from the time of emergence from the bud until either a pod was formed or the flower had wilted and fallen from the stem. The method of procedure in the experiment was as follows: At the beginning of the bloom period of alfalfa, during 1927, 1928, and 1929, ten representative locations were selected on the plats of the Experimental Farm. At each location 10 racemes having flowers about ready to expand into full bloom were chosen and labeled with jewelry tags. With a pair of scissors all of the flowers, except three or four, on each raceme were removed. A drawing was then made to indicate the position of the remaining flowers on the flower-stem; for identification purposes, each was assigned a number. The flowers were allowed to develop naturally; subsequent examinations were made at intervals of approximately 24 hours. In making the record of each flower, the letter "f" was placed in a column under the flower number for each day the flower remained in the full-bloom stage. The letter "w" was used to indicate the petals had become wilted and was used once for each day the flower continued in this condition. The letter "c" was used when the flower formed a seed-pod, and "x" to indicate that it had stripped. Observations on each flower ceased as soon as either of the latter two conditions had

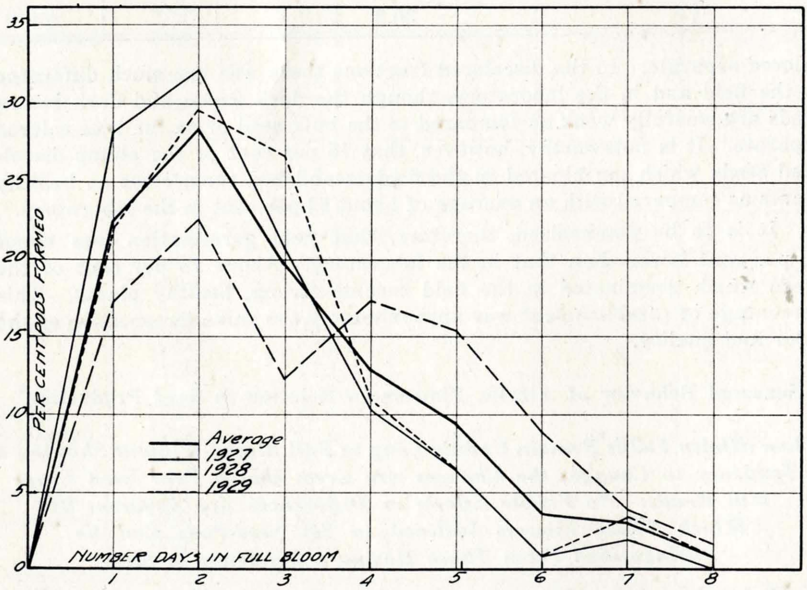

Figure 3—Showing the relationship between the number of days alfalfa flowers remain in the full-bloom stage and the percentage that forms seed-pods, for 1927-1929, inclusive. The curves take a rapid rise for the first two days and decline after the third day and indicate that from 52 to 80 per cent of the flowers that formed seed-pods, during these years did so after being from one to three days in full-bloom. This behavior of the flowers seems to be approximately the same each year, regardless of the seasonal variations of the weather and other factors influencing seed-setting in alfalfa.

occurred. A period of about ten days was necessary for all of the flowers to complete development, after which another set was labeled for observation. A total of 3354 flowers was observed during the three seasons.

Figure 3 shows in graphic form the relationship of the percentage of alfalfa flowers forming seed-pods and the number of days the flowers were in the full-bloom stage before the pods were formed. The curves take a rapid rise for the first two days and indicate that of the flowers that formed seed-pods in 1927, approximately 80 per cent did so after being in the full-bloom stage one to three days. The percentages are approximately 52 and 76 for 1928 and 1929, respectively. After the third day, the decline becomes rapid until the eighth day after which practically all of the remaining flowers stripped. The percentage data also show that, on the average, of those flowers remaining one day only in the full-bloom stage, three formed pods to each one that stripped. Of those remaining in the full-bloom stage three days, one formed a pod for each one that stripped. After being in the full-bloom stage more than three days, the odds favored the stripping of the flowers, as against forming of pods, and became larger with each succeeding day.

When the discussion regarding the varied nature of the weather for the seasons of 1927-1929, inclusive, is recalled, and the extremely close agreement of the lines in Figure 3 is considered, it would appear that alfalfa flower behavior and duration of stages are practically the same each year, regardless of the varied nature of the weather. Therefore, it would appear that the flower behavior is determined more by forces inherent in the flower than by those external.

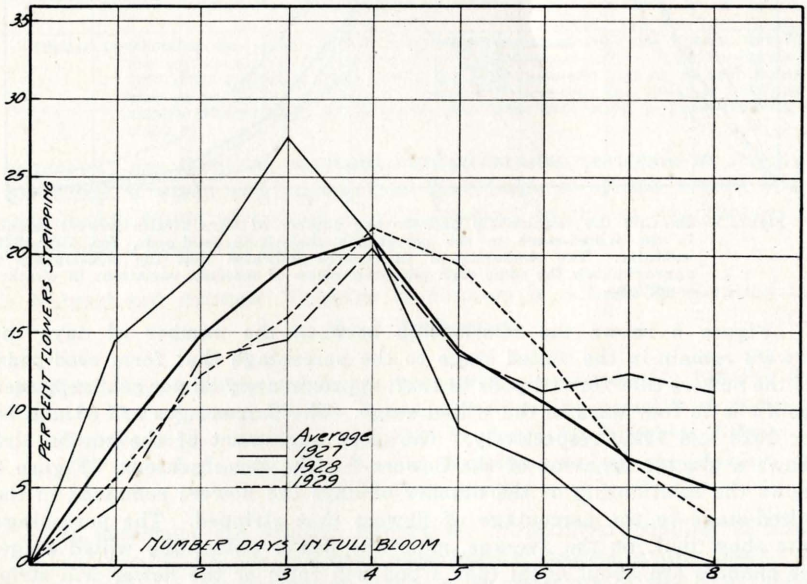

Figure 4—Showing the relationship between the number of days alfalfa flowers remain in the full-bloom stage and the percentage that strip, or fail to form seed-pods. In general, the curves resemble those of Figure 3, which would indicate a similar behavior for flowers that form seed-pods and those that strip. However, it appears that the full-bloom period is prolonged at least one day in the case of the flowers that strip as compared with those that form seed-pods.

Figure 4 shows the relationship of the number of days the flowers remain in the full-bloom stage to the percentage of flowers that strip. In general the curves resemble those of Figure 3, which would also indicate a similar behavior. Of the flowers that stripped in 1927, approximately 81 per cent remained in the full-bloom stage from one to four days. The percentages are approximately 52 and 54 for 1928 and 1929, respectively. It appears, however, on the average that alfalfa flowers remain in the full-bloom stage at least one day longer when they strip than when they form seed-pods.

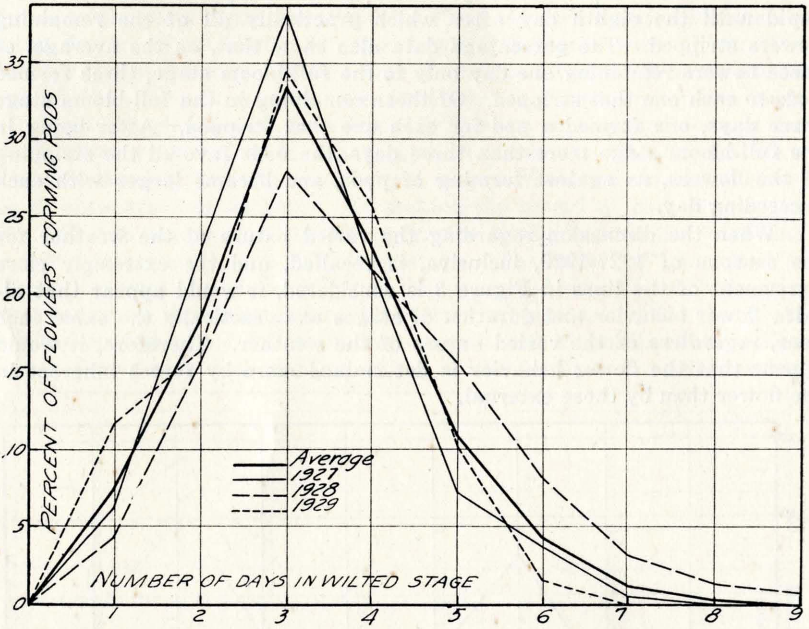

Figure 5—Showing the relationship between the number of days alfalfa flowers remain in the wilted-stage to the percentage that form seed-pods, for 1927-1929, inclusive. The similarity of the curves indicates that the relationship is approximately the same each year, regardless of seasonal variations in weather conditions.

Figure 5 shows the relationship between the number of days the flowers remain in the wilted stage to the percentage that form seed-pods. Of the flowers that formed pods in 1927, approximately 88 per cent remained from one to four days in the wilted stage. The percentages are 69 and 88 for 1928 and 1929, respectively. The close agreement of the curves also shows a similar behavior of the flowers for the three seasons. Figure 6 shows the relationship of the number of days the flowers remained in the wilted-stage to the percentage of flowers that stripped. The percentage data show that, on the average, after the flower enters the wilted stage, the chances are about equal that a pod will form or the flower will strip.

It would appear that no visible effects or differences in the behavior of alfalfa flowers are apparent by which those flowers inclined to set seed-pods can be distinguished from those having a tendency to strip. The differences in behavior while in the full-bloom stage and in the wilted stage are so small as to be useless as a basis for predicting the success or failure of the seed crop. In general, however, the period of activity of the alfalfa flowers appears to be relatively short, being approximately one to three days in the full-bloom period and two to four days in the wilted stage, which

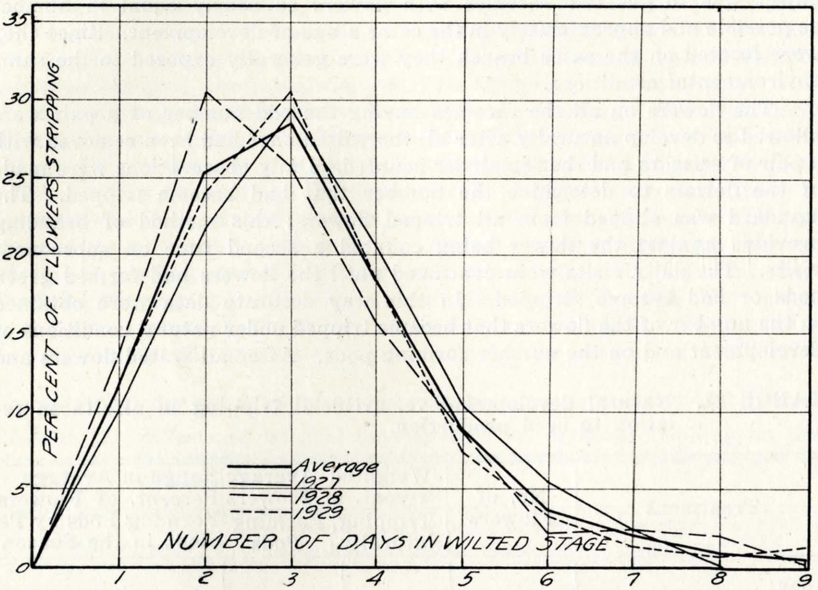

Figure 6—Showing the relationship between the number of days the flowers remain in the wilted-stage and the percentage that strip or fail to form seed-pods, for 1927-1929, inclusive. The curves for each year are similar to each other as well as to those of Figure 5, which indicates that the seasonal behavior of alfalfa flowers that set seed-pods and those that strip is approximately the same.

apparently are about the same for flowers forming seed-pods or stripping. Therefore, it would also appear that when fields of alfalfa remain unduly long in full bloom without showing a tendency to change, the chances are great that a poor seed crop will result.

Natural and Artificial Tripping of Flowers in Alfalfa in Relation to Seed Production

Artificial Tripping Resulted in an Increase of Approximately 140 Per Cent in the Percentage of Flowers Forming Pods as Compared With Natural Development. Artificial Tripping Produces No Injurious Effects Which Influence the Normal Development of the Seeds and Pods in Alfalfa

To determine the relative importance of artificial tripping in alfalfa for seed production, the following experimental procedure was used:

In 1926, ten representative locations on the plats of the Experimental Farms were chosen.[9] At each location five pairs of racemes were numbered

[9]Carlson, J. W., "Artificial Tripping of Flowers in Alfalfa in Relation to Seed Production." Jour. Am. Soc. Agron., Vol. 22:780-786 (1930).

1 and 2, 3 and 4, and so on to 10. Small jewelry tags attached to the base of the racemes were used as markers. Both members of a pair were always located on the same secondary branch of the mother plant, but the different pairs were not always placed on the same plant. In selecting a pair, the object was to get two racemes with flowers as nearly equal in number as possible and approximately in the same stage of development. Since they were located on the same branch they were generally exposed to the same environmental conditions.

The flowers on all the racemes having the odd number of a pair were allowed to develop naturally after all the wilted ones had been removed with a pair of scissors and the remainder counted. Daily observations were made of the flowers to determine the number that had become tripped. The standard was clipped from all tripped flowers; this method of branding provided against the flower being counted a second time on subsequent visits. The daily visits were continued until the flowers had formed green pods or had become stripped. In this way accurate data were obtained on the number of the flowers that became tripped under natural conditions of development and on the number forming pods. After all wilted flowers and

TABLE 21. Natural development vs. artificial tripping in alfalfa in relation to seed production.

Treatment	No. of Flowers	Weighted Average Percent. of Flowers Tripping Naturally	Weighted Average Percent. of Flowers Forming Pods	Range in Average Percent. of Flowers Forming Pods by Periods in the Season
1926				
Flowers developed under natural conditions (not enclosed)	740	6.2	25.6	
Flowers tripped by hand (not enclosed) (artificial tripping)	795		56.6	
1927				
Natural conditions	3740	11.7	39.1	36.8 to 41.5
Artificial tripping	2942		65.8	63.2 to 68.4
1928				
Natural conditions	8310	8.2	22.0	12.4 to 30.4
Artificial tripping	6560		69.3	64.6 to 74.0
1929				
Natural conditions	3651	6.4	10.1	4.5 to 21.5
Artificial tripping	3447		43.7	20.1 to 57.2
Summary of All Seasons				
Natural conditions	16,541	8.1	24.2	
Artificial tripping	13,744		58.6	

unopened buds had been removed and a count had been made of the remainder, those flowers on the racemes having the even number of a pair were tripped artificially, which was accomplished by inserting a pencil point into the throat of the corolla. All of the flowers on the same raceme were tripped in succession. No effort was made to prevent the pollen from one flower being carried to another. Some cross-pollination is likely to have occurred in the tripping process. Since all wilted and unopened flowers had been removed, the remainder could be tripped on the same day. Additional tripping upon successive days was not necessary. However, daily observation was made of the flowers to insure their being in a tripped condition. In rare cases it was found that the staminal tube had resumed its position within the keel and the flowers could be tripped a second time. It appeared that this occurred only in exceptionally young flowers which had perhaps been tripped prematurely. Almost without exception flowers tripped on one day would be found with wilted petals the following day. Artificial tripping appears to shorten the duration of the full-bloom stage in the development of the flower while forming seed-pods. The methods used to continue the studies were the same for the seasons of 1927, 1928,

TABLE 22. Effects of natural development vs. artificial tripping on the permanency of the pods and the number of seeds per pod in alfalfa.

Treatment	Percentage of Pods Formed Attaining Normal Maturity	Average No. of Seeds per Pod
1926		
Flowers not enclosed but developed under natural conditions (natural conditions)	41.0	Data not taken
Flowers not enclosed but tripped by hand (artificial tripping)	37.3	Data not taken
1927		
Natural conditions	88.9	2.94
Artificial tripping	91.0	2.25
1928		
Natural conditions	82.4	2.74
Artificial tripping	80.8	2.73
Summary of 1926-28 (By weighted averages)		
Natural conditions	70.0	2.84
Artificial tripping	69.5	2.49

and 1929, except that each season was divided into four or five periods, at the beginning of which a new set of flowers was labeled for observation. Table 21 contains in summarized form the data for the four years. For the 4-year period artificial tripping resulted in an increase of approximately 140 per cent in the percentage of flowers forming pods as compared with natural development. The data also show that only a small part, or an average of approximately 8 per cent, of the flowers that develop naturally become tripped, either automatically or through the aid of insects. It appears, therefore, that in the Uintah Basin in the absence of tripping, alfalfa flowers are capable of setting seed rather freely.

Data are given in Table 22 which show the effects of natural development and of artificial tripping in relation to the ability of the pods formed to develop to normal maturity as well as to the average number of seeds to the pod. The weighted averages in the summary show no significant differences in either of these characters. It is evident, therefore, from these data that artificial tripping produces no injurious effects which influence the normal development of the seeds and pods in alfalfa. Therefore, this method may be expected to result in a yield of seed proportional to the increase in the number of pods formed. No attempt has been made to discover methods of effecting the tripping in a manner that might be important economically. This problem suggests some interesting possibilities.

Air Temperature and Relative Humidity in Relation to Seed Production

Apparently, Alfalfa Might be Expected to Seed Best Under Desert of Semi-Desert Conditions, Where Warm or Hot Days, Cool Nights, and a Relatively Dry Air Both Night and Day Generally Are Encountered

In areas of Utah where alfalfa-seed production has become a major industry, favorable weather conditions are believed to repeat themselves year after year, in consequence of which there has been relatively uniform production over a period of many years. In general, when seed-crop failures occur in these areas, the cause is attributed to unfavorable weather conditions. An effort to gain some information as to what particular elements of weather influence seed-setting in alfalfa has been made at the Uintah Basin Alfalfa-seed Experimental Farm.

A self-recording hygrothermograph, of approved design and standard make, has been used during 1929 and 1930 for securing air temperature and relative air humidity records while alfalfa was in bloom and forming seed-pods. The instrument was placed in a shelter approximately 12 inches from the ground, so as to record with considerable accuracy the air temperature and relative humidity conditions immediately surrounding the alfalfa flowers. Due to unfamiliarity with the details of the problem during the initial stages of the investigation, the 1929 data are not valuable in suggesting any definite relationship existing between air temperature and relative humidity conditions, as influencing seed-setting in alfalfa.

On June 17, 1930, ten locations were chosen on the plats of the Experimental Farm, in the immediate vicinity of the shelter containing the temperature and relative humidity recording instruments. At each location,

TABLE 23. **Showing correlation coefficients between various conditions of air temperature and relative humidity and the percentage of alfalfa flowers forming seed-pods in 1929 and 1930.**

Conditions of Air Temperature or Relative Humidity	Correlation Coefficients 1929	r/P.E.	1930	r/P.E.
Average minimum daily temperature	—.0337±.3021*		—.2194±.0350	6.2
Average daily temperature	+.2703±.2908*		+.2324±.1225	1.8
Average maximum daily temperature	+.8023±.1077	7.4	+.2906±.1052	2.7
Maximum daily temperature	+.5252±.2190	2.3	+.4044±.1084	3.7
Minimum night temperature	—.3664±.2613	1.3	—.6425±.0534	12.0
Average minimum night temperature	—.3333±.2688	1.2	—.7297±.0606	12.0
Average night temperature	+.2621±.2816*		—.5450±.0385	14.1
Maximum night temperature	+.0980±.2995*		+.2492±.0080	31.1
Minimum daily relative humidity	+.1842±.2921*		—.7287±.0607	12.0
Average minimum daily (r) humidity	—.3375±.2655	1.2	—.7726±.0512	15.0
Maximum daily relative humidity	—.3308±.2652	1.2	—.5520±.0901	6.1
Average daily relative humidity	—.4908±.2295	2.1	—.8751±.0307	28.5
Average minimum night (r) humidity	—.2993±.2753	1.0	—.6776±.0701	9.6
Average maximum night (r) humidity	—.3460±.2662	1.2	—.3036±.1177	2.5
Average night relative humidity	—.3234±.2977	1.0	—.5661±.0880	6.4

*Less than 1 (not calculated).

nine or ten racemes, having an average of 12 flowers each, were marked for observation in relation to the percentage which formed seed-pods. At the time of marking, the flowers were just ready to emerge from the bud, or had recently emerged, so that the temperature and humidity conditions were measured for practically the full time after the flowers had left the bud stage until they either formed a pod or stripped. On the two following days similar sets of flowers were marked for observation, after which recounts to determine the behavior of the flowers with respect to pod-formation began with the set first labeled and continued on the two following days with those marked on the second and third days. As a rule, the majority of the flowers formed seed-pods or stripped by the end of eight to ten days after the time of marking them, but a few required a period of eleven or twelve days for this development. Approximately, one week after labeling the first three sets, additional ones were labeled on three successive days, and the recounts made for these sets were the same as for the first three. This procedure was continued at approximately 3-day to 6-day

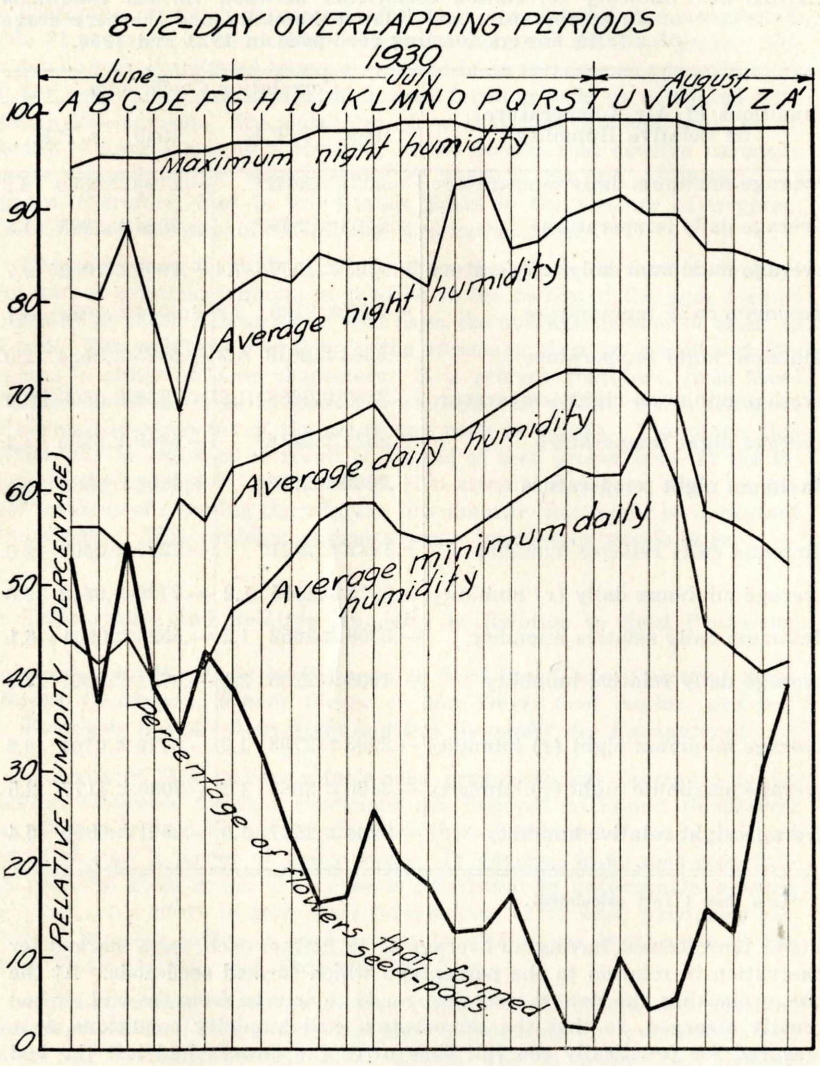

Figure 7—Showing the correlations between various conditions of day and night relative humidity and the percentage of alfalfa flowers that formed seed-pods in 1930. The study is based on an observation of 31,288 flowers. The correlations are all negative and are also statistically significant, as is shown in the data of Table 23. This would suggest that relatively dry air, both night and day, is most favorable for seed-setting in alfalfa.

intervals, until near the end of the 1930 seed season during which time 27 sets, including a total of 31,288 flowers on 2505 racemes and in 267 different locations, had been observed in relation to percentage of the flowers forming pods, as shown in Table 23. When the flowers had completed development to seed-pods or had become stripped, the temperature and relative humidity readings for the period as recorded by the instrument

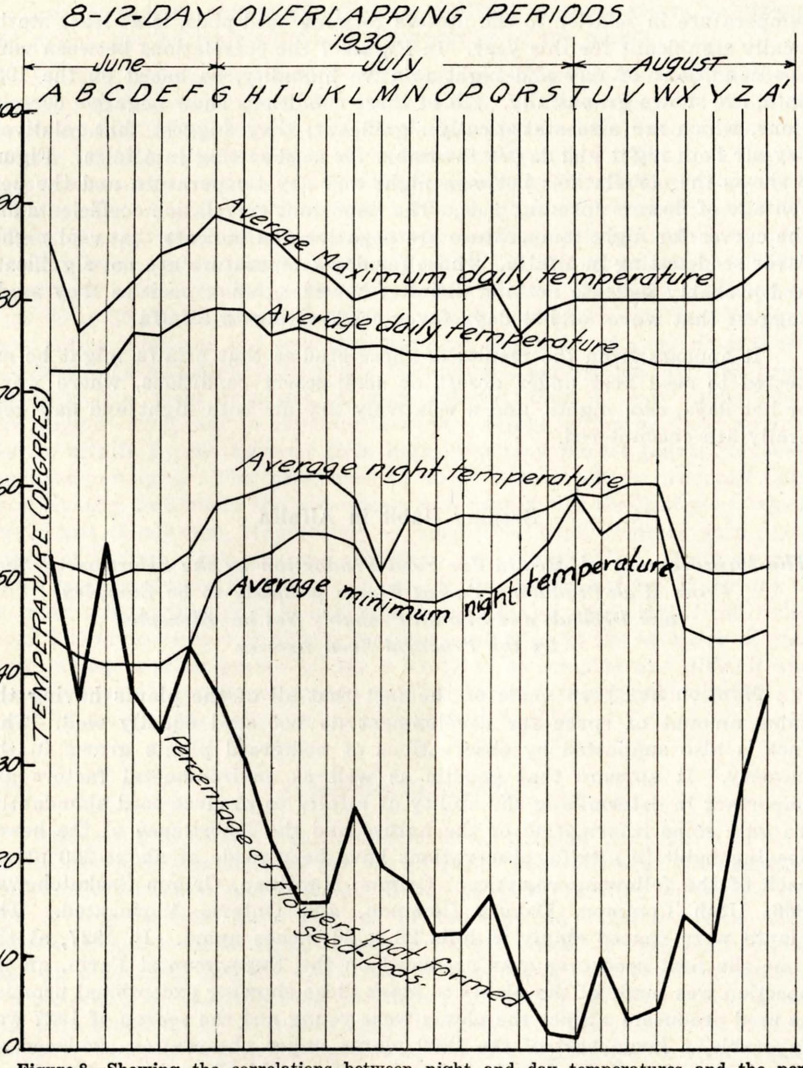

Figure 8—Showing the correlations between night and day temperatures and the percentage of alfalfa flowers that formed seed-pods in 1930. No definite correlations are found from these data for day temperature. Night temperature, however, gives statistically significant negative correlations, as shown in Table 23, and would suggest that cool nights are most favorable for seed-setting in alfalfa.

were read directly or by averages as was required. For the purpose of this experiment, day was arbitrarily defined as from 8:00 a. m. to 8:00 p. m. and night as from 8:00 p. m. to 8:00 a. m. The first reading for the day was made at 10:00 a. m. and was repeated at 2-hour intervals until 8:00 p. m. when the last reading was made. In a similar maner, the first reading for the night was made at 10:00 p. m. and the final one at 8:00 a. m.

The unreliable nature of the 1929 data has received mention. However, as shown in Table 23, one correlation, namely, that of the maximum daily temperature in relation to the flowers forming seed-pods, is at least statistically significant for this year. In Figure 7 the correlations between various conditions of day and night relative humidity, as based on the 1930 data, are shown graphically. All of these conditions show negative correlations, which are also statistically significant; they suggest that relatively dry air both night and day is favorable for seed-setting in alfalfa. Figure 8 shows the correlations between night and day temperature and the percentage of flowers forming pods. The important correlation coefficients and the curves for night temperature are negative and indicate that cool nights favor seed-setting in alfalfa. Those for day temperature are not significant and probably indicate nothing definite; however, being positive they might suggest that warm or hot days favor seed-setting in alfalfa.

It appears from the results of these studies that alfalfa might be expected to seed best under desert or semi-desert conditions, where warm or hot days, cool nights, and a relatively dry air both night and day generally are encountered.

Seeding Habit in Alfalfa

The Improvement of Alfalfa For Seed Production by the Selection of Seed From High-Producing Parent Plants is Likely to be Complex and Difficult and Should Probably Not be Attempted by the Practical Seed Grower

Mention has been made of the fact that all of the plants having the same amount of space for development do not seed equally well. This fact is also supported by observations of pedigreed plants grown in the nursery. It appears that genetic as well as environmental factors are important in determining the ability of alfalfa to produce seed abundantly. To gain some information of the nature and the inheritance of the heavy seeding habit in alfalfa, observations have been made of about 200 plants each of the following varieties: Grimm, Hardigan, Grimm Saskatchewan 666, Utah Common, Dakota Common, and Ontario Variegated. The plants were spaced singly in hills 28 x 36 inches apart. In 1927, at the time the first seed crop was produced on the Experimental Farm, an inspection was made of the plants to mark those showing exceptional promise as seed producers. Since the plants were young and the season of 1927 was favorable, a large part of the 1200 plants under observation produced an abundance of well-developed seed-pods. The yield of seed was not determined for each individual plant, but about 100 of those that appeared to show the strongest seeding tendency were marked with a stake, so as to be easily identified the following season. In 1928, approximately all of the 1200 plants were again studied. A few plants which had not been observed as having special merit in 1927 showed exceptionally strong seeding tendencies in 1928. Two such plants were discovered when they produced seed exceptionally well after the entire plants had been enclosed in wire-screen cages 30 x 30 x 36 inches, which were being used to exclude insects from the flowers at blossom time. An effort was being made to produce close-fertilized seed; the method, however, had resulted in poor yields of seed. It was believed that if the plants were able to seed well under a cage, the genetic factors responsible for the seeding tendency might be strong and might also be transmitted to the progeny of the plants.

In 1928, open-grown seed (not forced to self-pollination by artificial means) was harvested from 17 plants which, as shown by the yields of the seasons of 1927-1930, inclusive, have since appeared to possess a natural seeding tendency which is able to express itself and to offset to a degree certain seasonal variations which with the majority of alfalfa plants result in low yields of seed. In 1929, seed was saved from approximately 30 additional plants, which had shown a strong seeding tendency over a shorter period. Three systematically replicated plats, 5 x 34 feet or nearly 1/256th of an acre, were sown from the seed of each plant. The plats consisted of from 40 to 50 plants spaced in hills 18 x 24 inches apart. At harvest time each entire plat was cut and threshed and the yield of seed determined in ounces. These weights were then calculated to acre-yields. In their present form, the yield data are of more interest than of real value, since they suggest what may be expected from an attempt to improve seed production in alfalfa by saving seed from high-producing parent plants for sowing seed-acreages. The progenies of those plants which produced seed exceptionally well under the wire-cages gave acre-yields the first year, which are 37 and 43 per cent, respectively, of unselected Utah Common seed. One strain of Grimm Saskatchewan 666 gave an acre-yield for the first year which is approximately 192 per cent and is the only one of the 17 strains to show an outstanding gain in comparison to those of unselected Utah Common. The improvement of alfalfa for seed production by the selection of seed from high-producing parent plants is likely to be complex and difficult and should probably not be attempted by the practical seed grower, being apparently one for the geneticist and the plant breeder.

Variability in Alfalfa

Inbreeding in alfalfa was accomplished by causing the seed to be self-fertilized, which was done by the use of paper bags put over the branches before the blossoms had opened. Branches were selected on which the tips of the blossoms were well out of the bud; any flowers which were mature enough to have begun to open were clipped off, thereby enclosing in the bag only those flowers which had no opportunity for cross-pollination. Parent plants of the following varieties were grown in rows 3 feet apart and with plants 27 to 40 inches apart in the row: Utah Common, Dakota Common, Grimm, Grimm Saskatchewan 666, Hardigan, and Ontario Variegated. These varieties represent a wide range in size, coarseness, leafiness, and erectness.

Seed production under bags, as a rule, is relatively poor, but in seasons, such as 1927, moderately favorable for seed-setting, some seeds were obtained from most plants on which five to ten bags had been placed. In 1927, a few plants failed to produce any seeds under bags even when seeding well in the open air. Of approximately 180 plants so bagged, seeds were obtained from 154, of which 88 produced 50 to 100 seeds under bags. In 1928, the selfed-seed from each parent plant was seeded in a single row of 50 plants when there were enough seeds. When the number of seeds obtained was fewer than 50 all of them were sown, one in a place. There were a few rows with only 1 to 5 or 6 plants, though in most cases 10 to 40 plants were obtained.

When these first-generation plants from self-fertilized seeds blossomed for the first time, some of them were bagged in order to produce second-generation selfed-seed, from which progeny rows were seeded in 1929.

In 1929 it was observed that of the plants grown from selfed-seed, those in some rows were variable, fully as much so as the parent varieties, whereas the plants in other rows seemed to be much more uniform in erectness, height, diameter of stem, size and shape of leaves, and color of blossoms and foliage. Measurements were taken of 40 plants in each of the parent rows and of all the plants in the progeny rows. Five rows of the Utah Common variety were measured—two near the breeding plats and one each from three different parts of the field but some rods away. Data were taken from each plant as to height, width, angle of erectness, diameter of a main stem 3 or 4 inches above the ground, leaflet length, leaflet width, color of the blossoms and of the foliage. The colors were read from a standard color chart and assigned numerical values with the help of an artist. The variability of each row was computed as the standard deviation and as the coefficient of variability.

The variability of the varieties is reported in Table 24 and is expressed in percentage of the mean values of each character studied. Only the variability is reported in order to show uniformity or lack of it.

TABLE 24. Coefficients of variability for plant, stem, leaf, and bloom characters of alfalfa varieties with 40 plants in each row measured.

Variety	Percentage						Color of Bloom Standard Deviation
	Plant Height	Plant Width	Angle of Erectness	Diameter of Stem	Length of Stem	Width of Leaflet	
Utah Common	19.7	18.5	22.4	11.2	12.2	18.0	2.93
Utah Common	22.2	18.8	18.0	18.4	15.1	25.7	3.03
Utah Common	19.9	26.0	21.7	17.1	13.4	26.8	3.35
Utah Common	16.6	24.4	12.0	15.3	17.6	23.7	3.59
Utah Common	21.8	26.1	17.0	18.0	13.2	21.8	2.65
Grimm	22.9	26.9	15.0	18.8	17.2	23.6	10.80
Grimm Sask.666	26.9	31.4	25.3	19.2	17.6	24.8	6.66
Hardigan	22.0	24.2	14.2	19.3	14.9	25.7	5.87
Dak. Common	21.9	25.8	7.6	16.2	12.1	21.4	2.37
Ont. Variegated	25.0	25.3	20.0	20.8	17.8	21.3	6.66

The result of a generation of inbreeding is summarized in Table 25 where the variability is reported for progenies. Comparing plant height and width in the two tables, it is clear that some of the progenies are similar to the parent varieties while others are distinctly more variable and others distinctly less. This is true of each character studied, even for blossom color. There is every evidence of segregation of distinct strains of alfalfa at the end of the first inbred generation. This indication is so definite that high hopes are held for producing improved sorts after several generations of inbreeding. The second inbred generation shows rather marked tendencies to the further purification of some strains, but since these data are not yet available they can be only noted here.

TABLE 25. Variability of progeny rows of alfalfa, each grown from self-fertilized seed of a single plant of one of the varieties shown in Table 24. Three plants each of the highest, of intermediate, and of the lowest variability of each character.

Variability Group	Plant Height	Plant Width	Angle of Erectness	Diameter of Stem	Length of Leaflet	Width of Leaflet	Color of Bloom
Highest	38.2	45.6	50.7	25.7	27.5	23.7	12.19
Highest	36.7	43.8	46.2	22.0	26.8	29.6	10.64
Highest	30.8	39.4	44.6	21.1	18.9	28.8	10.15
Intermediate	20.8	22.9	21.1	14.2	12.6	16.7	4.35
Intermediate	19.9	20.8	23.1	13.8	11.9	16.7	3.83
Intermediate	18.4	21.2	19.5	13.3	11.2	15.5	3.33
Lowest	9.3	11.0	8.6	8.5	7.1	11.2	1.22
Lowest	9.6	11.2	7.8	6.1	6.6	10.3	1.10
Lowest	7.9	7.5	7.0	4.5	4.8	9.0	0.0

Inbreeding which tends to purify the various sub-varieties, or strains which make up a variety, allows for the appearance of any abnormalities which in open pollination (such as occurs in the field) are obscured by being in a crossed condition with normal types. In the first inbred generation, three rather distinct sorts of abnormal plants have appeared.

Each of two progenies, both from the same parent strain showed several plants on which the leaflets had tiny brown markings not characteristic of any recognized disease when examined by a plant pathologist. The leaves, partly folded and partly crinkled, suggested that small sections of the leaf structure had been lost or had died after development had started. Sufficient study has not yet been made to enable more to be said at the present.

In three other progenies there occurred some distinctly shorter plants extraordinarily leafy but which would produce only about half as much hay as the parent variety. One strain of nearly normal size showed in a large degree this same condition of extreme leafiness.

In a single progeny almost half the plants had the blossom replaced by a freak vegetative development that resembled somewhat the appearance of the flower buds on a plant of seed onion. This condition occurs naturally in the field at rare intervals. Here a progeny was found in the first inbred generation in which the freak character was thousands of times more frequent than is found in the commercial varieties or strains.

Improvement of Alfalfa by Inbreeding

Judging from the history of corn and timothy breeding and from the ready yielding of alfalfa to segregation in its first inbred generation, it is thought that considerable improvement in alfalfa for hay and for seed production might be accomplished by applying modern plant-breeding methods to this crop. There seems little doubt that in a few generations a strain with fine, leafy top growth could be obtained. Some strains are becoming pure for erectness, while others are pure for a nearly flat position; others are showing a strong tendency to coarseness and still others to a suggestion of "vininess" in the upper branches. This last character suggests a faint resemblance to twining branches such as occur on vetches and some beans.

As shown previously, there is also considerable evidence that seeding ability in certain strains is governed in part by the genetic constitution of the plants.

While it would require an immense amount of careful scientific work to develop and maintain such strains, the promise from this sort of work is such as to warrant its being given a thorough trial.

SUMMARY

1. Seeding alfalfa in rows resulted in an acre-yield of seed approximately one-third greater than the drilling method.
2. Growing alfalfa in hills for seed production gave an increase in acre-yield of seed of approximately 44 and 76 per cent, as compared with the rows and drilling methods, respectively.
3. Alfalfa drilled so as to produce a thin stand of plants gave a higher acre-yield of seed than did the heavier rates of seeding.
4. For best results in seed production, clipping of the first-growth alfalfa should not be delayed beyond the beginning-of-bloom stage and pasturing-off should not be continued later than the end of May.
5. Various methods of cultivating alfalfa produced no important differences in the acre-yield of seed. However, spring cultivation aids in the control of weeds and insect pests.
6. A limited water-supply which will produce a slow and even vegetative growth is most desirable for seed production in alfalfa. The amount required will probably vary with soil conditions and with the seasons.
7. The acre-yields of seed were highest for those plats receiving no manure and lowest for those receiving 15 tons of manure.
8. Winter-hardy varieties, such as Grimm and Hardigan, can be expected to be equally as good seeders as less hardy ones, such as Peruvian and Argentine. Utah Common does not appear to differ greatly in seeding habit from those varieties having the quality of winter-hardiness or lacking it.
9. It appears that stacking cannot be expected to improve greatly the quality of seed cut in an extremely immature condition. Quality in alfalfa-seed apparently varies as a result of seasonal conditions more than it does as a result of differences in production methods.
10. When grown under favorable field conditions, true-colored and plump alfalfa seed has a germination value of approximately 51 per cent; plump discolored seed has a value of 29 per cent; and shriveled discolored seed a value of approximately 16 per cent. Irrespective of color or plumpness, approximately 75 per cent of the alfalfa-seed that germinated in the field established strong and healthy seedling plants.
11. When alfalfa fields remain unduly long in full bloom without showing a tendency to change, the chances are great that a poor seed crop will result. No visible effects or differences are apparent by which those

flowers inclined to set seed-pods can be distinguished from those having a tendency to strip.

12. Artificial tripping resulted in an increase of approximately 140 per cent in the percentage of flowers forming pods as compared with natural development. Artificial tripping produces no injurious effects which influence the normal development of the seeds and pods in alfalfa.

13. Apparently, alfalfa might be expected to seed best under desert or semi-desert conditions, where warm or hot days, cool nights, and a relatively dry air both night and day generally are encountered.

14. The improvement of alfalfa for seed production by the selection of seed from high-producing parent plants is likely to be complex and difficult and should probably not be attempted by the practical seed grower.

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